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THE MAPLE SUGAR INDUSTRY.*

From time unknown, the Indians tapped the maple trees for sugar. This they did by making a diagonal cut in the trunk of the tree, and driving a reed or concave piece of bark into its lower end, to convey the liquid into a bark trough or other receptacle. The sap was boiled down in clay or bark vessels by repeatedly dropping hot stones into it. It is said that they had sufficiently developed the art to store the sap in large troughs made of elm bark, and to keep up a continuous production throughout the sap season. For a hundred years or more conditions did not allow the improvements is the utilization of steam for boiling down the sap.

The sugar maple spreads over a wide area, but as a tree for the production of sugar in paying quantities its range is limited to western New England, New York, Pennsylvania, the southern Appalachians, the Ohio valley, and the Lake States, and adjacent parts of Canada. In the Gulf States and as far north as southern Arkansas, the tree is represented by a variety (*Acer saccharum floridamum*) from which no sugar is made. The sugar maple is a stately and vigorous forest tree capable of growing in dense stands. It bears a plentiful crop of seeds, which in most localities ripen depth of the tap-hole to the amount of sap secured has been a point long in dispute among sugar-makers. A nearly uniform depth of about one inch is now generally used, as the sap is found almost entirely in the living or sap wood, which in the mature maple is confined to about twenty-five or thirty annual rings, or from two to three inches of the outer wood, according to the tree. Professional sugar-makers consider the sap from shallow holes of better quality than that from deep ones, and long experience and observation have resulted in this adoption of one inch as the proper depth.

The spouts should be of metal, preferably of mallea-

ADIRONDACK SUGAR MAPLE.

A productive tree in the sap season. Modern buckets properly hung.

BOILING MAPLE SAP IN THE WOODS.

MODERN STEAM EVAPORATOR.

The sap is reduced by its passing over steam pipes in the pans.

THE MAPLE SUGAR INDUSTRY.

white settlers to change materially the Indian method of producing maple sugar, save by the substitution of iron or copper vessels for those of clay or bark and by the use of better utensils. Even the most progressive settlers did little more than introduce greater cleanliness into the old crude method. The boiling was generally done in the open woods, with no shelter from sun, rain, and snow. Converting the syrup to sugar was known as "sugaring off," and consisted in further boiling down the thin syrup until it would become waxy if dropped on snow. It was then ready to be poured into molds, where it crystallized into sugar. In the course of time, however, the industry assumed commercial importance in the Northern States, with Vermont, New York, and subsequently Ohio, leading in production. With the increasing demands for maple products, a rapid betterment in the methods and machinery took place, and to-day these improved processes are almost universally practised. The latest of these in the early fall, and germinate readily under favorable circumstances.

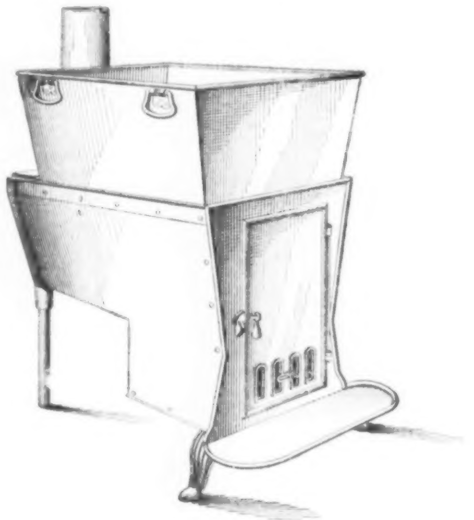
The sap season throughout the maple sugar belt of the United States generally begins about the middle of March and continues until the third week in April, but it varies very widely with a late or an early spring. Before the sugar season opens, the necessary stock of dry, well-seasoned wood for fuel should be provided. Spouts, pails, gathering tank, storage tank, and evaporating pans should be thoroughly cleansed by scalding them with boiling water. Before tapping a tree, any loose bark which may fall into the sap should be brushed away from the trunk by means of a stiff broom or other brush. A hole one inch in depth and three-eighths or half an inch in diameter, directed slightly upward to insure drainage, should be bored on the sunny side of the tree, if possible, and avoiding defects or old scars made by previous tapping. Trees under twelve inches in diameter at breast height should not be tapped, and except in very few cases, there should be but one spout to a tree. The relation of the ble iron, and heavily tinned. These are more lasting, but tin ones can be obtained at a slightly smaller cost. Wooden spouts, usually made of elder or sumach from which the pith has been removed, should be made before the sap season, and stored in a cool place where they will not check or warp. Sap pails should be of tin or galvanized iron; wooden ones are less durable and harder to keep clean. If the latter are used, the pails should be enameled white on the outside as a protection against heating by the sun. It is best to keep the pails covered, as impurities in the sap will result in the darkening of the sugar and syrup. It is well to have the covers reversible, with one side painted red and the other white. By turning the red side up when the pail is empty, the gatherer will know it does not require his attention. When covers are used, a pail is hung to the spout by a hole in its rim, the sap thus falling into a closed space with less danger of evaporation and souring. It is usually advisable to throw away the first drippings, which are apt to contain impurities.

* Abstracted from Bulletin No. 59 of the Bureau of Forestry, Department of Agriculture.

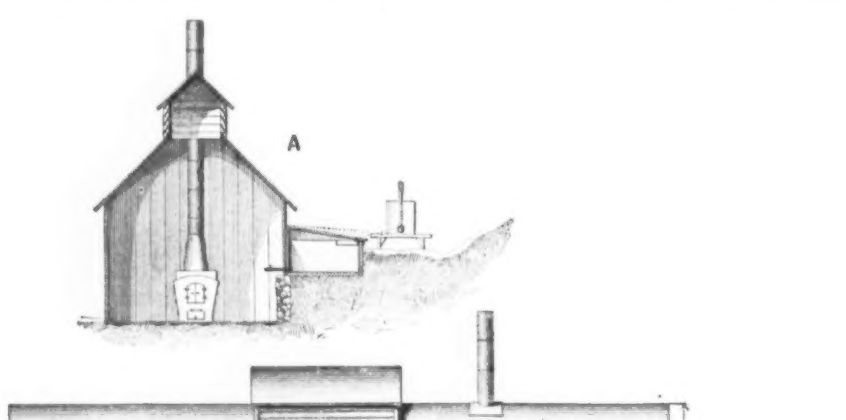
The first requisite for transporting sap to the sugar house is a good system of roads throughout the sugar bush, as in some respects the sap is as delicate a product as milk, and the method of bringing it from the tree to the storage tank must be rapid and systematic. In small groves the carrying can be done by hand, of course, or with the old shoulder yoke, but with larger operations the transportation must be effected by horses, steam power, or gravity, and must be fully organized. The tank should be metallic; but if of wood, it should be painted white on the outside to keep the sap cooler and prevent souring. The storage tank should be of tin, or galvanized iron incased with wood and properly covered. Every practicable precaution should be taken to keep the sap in good condition and free from impurities. As it is very sensitive to changes in the weather, and is likely to sour if it becomes heated, it should be collected regularly and as soon as possible after it has left the tree. The gathering tank should have a strainer over the mouth, and the storage tank should be kept at an even temperature, even if it must be cooled with ice during a sudden period of heat. Advantage should be taken of every opportunity to wash and scald the tanks and evaporators.

The sugar house is the most important adjunct to the grove, and should be planned with reference to the scale of operations undertaken. If only a few trees are tapped, the work may be carried on in the old-fashioned way, but even in such a case it is better to have a small one-room house with a woodshed. In this room the small evaporator and sugaring-off kettle may be placed, and the work carried on satisfactorily. Where a large grove is to be operated, a two-room house with a woodshed is necessary. It is always well to put the sugar-house on sloping ground and, of course, in the most convenient place in the grove. If the ground rises above the house, the storage tank can be readily filled from the gathering tanks, and at the same time feed by gravity into the evaporator. If the grove be on level ground, it will generally pay to make an artificial elevation upon which to place the storage tank, with room for the sledges to pass and discharge sap into it. If 1,500 trees or more are to be tapped, it will be found to be of advantage to have a house with two compartments and a woodshed something after the general plan shown in the illustration. The evaporator room should form the middle compartment; the room for sugaring off should adjoin it at one end, and the woodshed at the other.

The best modern evaporators are made so that the sap feeds automatically into the pans, running fast or slow according to the heat under the latter, and the flow ceases entirely when the fire gets low. The pans average about 6 inches deep, 40 inches wide, and from 10 to 18 feet long. They are often made with corrugated bottoms to increase the heating surface. Partitions from side to side and open at alternate ends are placed in them at intervals of from 8 to 10 inches. The sap, whose flow from the storage tank is carefully regulated, enters the evaporator at one end and flows slowly across the pan from side to side around the partitions until it reaches the far end. The sap in the pans should be kept very shallow, the best results being obtained from a depth of $1\frac{1}{2}$ inches at the upper end and 1 inch at the lower. The impurities rising to the surface should be skimmed off frequently and with greatest care, so that by the time the syrup reaches the lower end of the pan it may be perfectly clear. A temperature of about 219 deg. F., varying slightly with the altitude of the sugar house, or a weight of 11 pounds to the gallon, is proper for good syrup. When this is reached, the syrup should be dipped out and carefully strained through flannel, a procedure which has proven very efficacious, to remove the malate of lime or "niter," which forms as a deposit at the above-mentioned temperature. After 10 or 12 hours' boiling, the two rear sections of the evaporator will become more or less coated with the niter, which may be easily removed by simply turning the pan about, putting the coated sections toward the cold sap and the clean section in the rear. In an hour or so the boiling sap will dissolve and remove the lime, all of which will be caught in the flannel strainers. Particular care should be taken to see that the syrup finishes at the proper temperature and weighs 11 pounds to the gallon, careful tests being made with the scales and the thermometer to insure this. The syrup should be stored in large tanks and allowed to settle, though if flannel strainers are used it will contain but little sediment.



MODERN SUGARING-OFF ARCH.



PLAN OF MODERN SUGAR HOUSE.

A. Sectional view, showing evaporator, storage tank, and gathering tank (on sled). B. Elevation. C. Ground plan.

THE MAPLE SUGAR INDUSTRY.

Improvements in the method of firing have kept pace with those in boiling. From the old rough firebox has been evolved the modern portable arch, made of iron with a flue running beneath the evaporator. It is lined with firebrick, and has gratebars and accurate dampers, so that the heat is more regular, while no smoke is allowed to escape. Its economy of fuel is many times greater than that of the old firebox. In the latest improvement in syrup making, a series of steam pipes is placed in the evaporating pan, and the sap made to flow over and around them. The process is most effective and cleanly, but of course can be carried out only where sugar is made on a large scale.

It is a much-mooted question whether the syrup should be put up for the market hot or cold. While both methods are used by experienced makers, it has been generally observed that syrup put up hot shows a greater tendency to crystallize, and it is usually more satisfactory to put it up cold. In either case it should be canned or tightly inclosed as soon as practicable. Square, oblong, or round cans containing a gallon, half-gallon, or quart are used. The cans should be tipped slightly and filled to the top, then lifted so that the bottom may sag and the sides bulge out slightly, and more syrup poured in until the receptacle is completely filled. It is held thus while the cork-lined screw cap is turned down as tight as possible. The can should then be laid on its side for a period to see if there is any leakage.

In making sugar, the syrup should be reboiled in a sugaring-off arch until it begins to crystallize or "sugar off." By the old-fashioned method this point was determined by pouring a little syrup on the snow, or by dipping into it a twig bent in a loop. If the syrup became waxy on the snow, or if it formed an elastic film within the loop, it had boiled enough and was ready to "sugar." Under more modern methods the testing is done with a thermometer, and sugar is made at different temperatures, 238 degrees to 253 degrees, according to the quality wanted. The most convenient size and form for sugar is in one to five-pound bricks, and in ten-pound pails for family use. Sugar put up in bulk is likely to fall into the hands of the mixer at a low price. That in small and attractive sizes is better adapted for personal use, and is acceptable to the wholesale and retail trade. The bricks should be wrapped in paraffine paper, and the tubs or tin pails hermetically sealed. Sugar and syrup should be stored in a cool dry cellar or storeroom, as excessive heat is bad for them, particularly a combination of heat and moisture, which causes the sugar to mold, and the syrup to ferment.

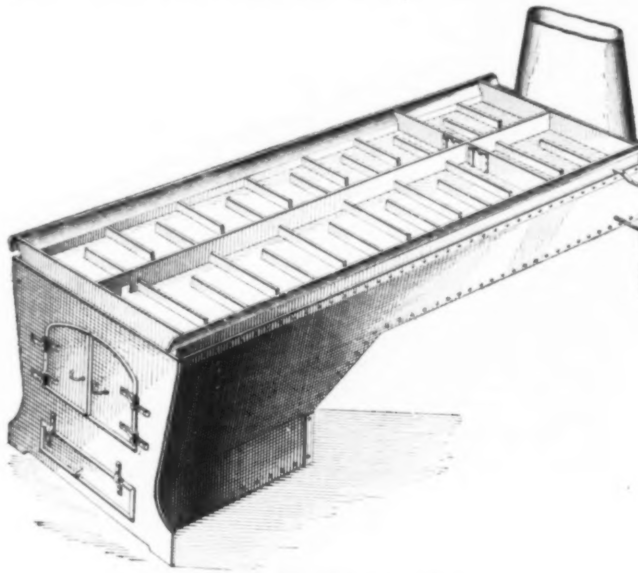
THE UTILIZATION OF PEAT.

There is no doubt that, apart from political considerations, the chief reason for the striking difference between the prosperity of the populations of Great Britain and Ireland is due to the comparative absence of manufactures in the latter country. The reasons for this industrial backwardness are not far to seek. Although enjoying equal geographical advantages and a mild and equable climate, the island lacks the abundant coal supply with which England is endowed. At one time practically the whole of Ireland must have been covered with coal-bearing strata; overlying the rocks of carboniferous limestone, which constitute the chief geological formation; but in place of the coal measures, we now find deposits of boulder clay, sand, and gravel, bearing witness to the action of ice and water, by whose agency the land has been robbed of such a valuable inheritance. Remains of the former coal measures are still to be found in various parts of the country, particularly in the northeast and southwest corners; but the total output is only about 125,000 tons yearly, as against the 225,000,000 tons raised in Great Britain.

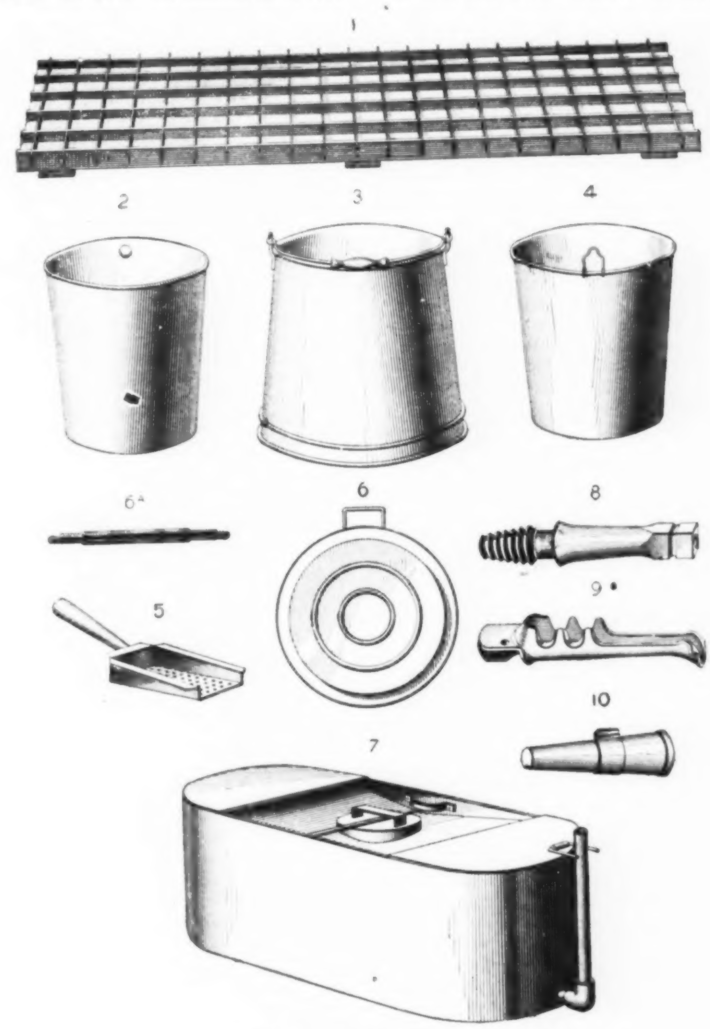
The absence of coal is more to be regretted in view of the fact that the country is particularly rich in deposits of iron ore, which lie idle on account of the lack of suitable fuel for smelting. Formerly the ore was reduced on a considerable scale by the use of charcoal obtained from the forests with which the country was at one time covered; but this source of fuel is no longer available, and for over a century the manufacture of iron has been practically extinct. Nothing, again, but the fuel difficulty appears to stand in the way of the cotton industry thriving in Ireland, as it does in Lancashire. The humidity of the climate of Lancashire, which is usually credited as being the most potent factor of the success of its cotton trade, is at least equaled on the other side of the channel, and raw material could be delivered there, if anything, more cheaply than on this side.

A possible source of fuel for these and other purposes is to be found in the vast peat bogs which cover a great proportion of the interior of the country. These bogs vary from 20 feet to 30 feet and more in thickness over a total area of about 2,500 square miles, while comparatively thin deposits, found in the more mountainous districts, cover an additional area of about 1,900 square miles. It will be seen that if peat could be rendered available for fuel on a commercial scale, a great future awaits the industry; and if the prophesied exhaustion of our own coal supplies should eventually come to pass, the question of the utilization of peat would immediately become of vital importance to the manufacturers of this country.

In composition, peat partakes much of the nature of wood. When dried, it is found on analysis to contain about 60 per cent of carbon, 33 per cent of oxygen, and 6 per cent of hydrogen. The carbon is thus present in only about two-thirds the quantity found in bituminous coal, while the oxygen is from twice to ten times the amount, the hydrogen in the two cases being about the same. Air-dried peat has, on an average, only one-half the calorific value of coal, while even when kiln-dried the proportion does not exceed two-thirds. It



MODERN MAPLE-SAP EVAPORATOR.



SUGAR-MAKING UTENSILS.

1, Sugar mold; 2, 4, sap buckets; 3, gathering pail; 5, skimmer; 6, cover for sap bucket; 6a, cross section of same; 7, gathering tank; 8, 9, 10, sap spouts.

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thus compares rather unfavorably with coal so far as heating properties are concerned, and its greater bulk and crumbliness make it less suitable for storage and transport, although these disadvantages are to some extent compensated by the fact that, being found on the surface, deep underground workings, with the heavy working costs thereby involved, are unnecessary. As a fuel it has advantages over coal in the very small amount of sulphur present, and the entire absence of slagging. Its freedom from sulphur renders the iron from peat-fed blast-furnaces equal in quality to the best charcoal iron, and the quantity of oxygen present in the substance makes a smaller air-supply necessary, hence reducing the wasteful passage of nitrogen through the fuel.

The most serious drawback to its use, however, consists in the enormous quantity of water always contained in it in its natural state. When cut from the bog, water is present to the extent of nearly 90 per cent by weight, and even after standing in stacks in the open air until, as far as can be seen, they are perfectly dry, the sods still retain over 25 per cent of moisture. Furthermore, in this condition, it is very bulky and friable; and though the cost of digging and stacking it is extremely low, before peat becomes a marketable commodity other treatment, with the object of drying and consolidating it, is necessary.

On the Continent of Europe, the treatment commonly consists in grinding or mincing the sods immediately they are dug, until the substance is reduced to the condition of a thick mud, which is made into bricks, the latter being piled in stacks and dried in the open air for a month or two. Peat bricks made in this way resemble lignite in appearance and density; but when as dry as they can be got, they still contain over 20 per cent of moisture. They are sufficiently hard to stand a reasonable amount of handling, and may be stored without deteriorating. Bricks thus prepared are used in large quantities all over the Continent as a substitute for coal where the latter is dear, the fuel being found suitable for both locomotive and stationary boilers, chemical works, breweries, etc., as well as for domestic heating.

A further improvement in the preparation of peat consists in compressing it hydraulically into hard compact briquettes. At first sight, this would appear to solve the problems of extracting moisture and reducing bulk and brittleness at the same time, but a succession of failures have demonstrated the impracticability of expelling the surplus water, even after air-drying, by this means. Peat containing 77.7 per cent of water leaves the press with nearly 63.5 per cent still present after having been submitted to a pressure of 2 tons per square inch. Most exhaustive experiments have been made, particularly in Germany, with the object of making the plan workable; but the results are given in a report by Mr. J. G. Thaulow to the Norwegian government in June, 1902, as having been a complete failure. The report states that it proved difficult to reduce the water even to 66 per cent by pressure alone, and the process required so much capital expenditure and such high running costs to obtain such indifferent results, that the expense was out of all proportion to the output. Another method of extracting water is by the use of centrifugal machines, but this, again, fails to produce the required degree of dryness. It would appear that the only solution of the problem lies in supplementing the tedious air-drying by using artificial heat to drive off the residual water. Dryers designed for this purpose consist of an iron cylinder from 3 feet to 5 feet in diameter by about 30 feet long, revolving on gudgeons at each end. Beneath this cylinder is a furnace, the hot gases from which pass down the entire length of the casing, and return through the interior in contact with the peat. The draft is maintained by a fan at the outlet, which also removes the evaporated water. The peat before entering the drum is disintegrated by a machine, and as the drum is inclined at a slight angle, the contents slowly travel to the lower end, under the influence of gravity. The Simpson dryer, in use on some of the Canadian peat bogs, is rather more elaborate. From a description contained in an article by Mr. W. E. H. Carter, published in a report of the Bureau of Mines, Ontario, it is seen that this form of dryer contains two revolving drums, 30 feet long, situated one above the other, and both inclined slightly to the horizontal. Both drums are fitted with baffle-plates for stirring up the peat. The latter is fed into the lower cylinder, thence into a pan-conveyor, which carries it back between the cylinders, and discharges it into the upper one. After its passage through this, it is delivered into a shoot leading to a breaker. The hot gases from the furnace beneath never come in contact directly with the peat, and hence the greater proportion of the volatile constituents are retained. The cylinders are driven by chain gear, the upper one making three revolutions per minute and the lower one nine, a charge of peat occupying twenty minutes in the entire passage. As regards efficiency, it is claimed that the Simpson dryer will reduce the amount of water in peat from 50 to 10 or 15 per cent, consuming not more than 200 pounds of air-dried peat as fuel per ton produced.

An electrical process of drying peat has been proposed, and we understand that a plant is now being erected in Ireland for the purpose of carrying out the idea on a commercial scale. After a certain amount of water has been extracted by a centrifugal machine, electrodes are inserted in the peat mass and current from a dynamo passed through for some time. The current heats the mass on account of its resistance, and is further claimed to rupture the cellular fibrous matter, and thus assist the final consolidation. It will be very surprising if such a process can compete successfully with heating by the direct action of fuel; for whereas one unit of electricity cannot possibly develop more than 3,410 heat units, and at present requires about 3 pounds of coal to produce, the direct combustion of the same coal would develop about thirteen times the amount given back on degrading the electricity into heat.

The peat, after being dried and disintegrated, has next to be formed into small dense briquettes. The most convenient shape for these is cylindrical, having a diameter of 2 inches to $2\frac{1}{2}$ inches, and of equal depth. The presses used for this purpose are of two kinds: one in which the descending ram drives a certain quantity of peat into a die with a closed bottom, and the other in which the die is in the form of an open-ended tube about 12 inches long. The latter type, known as the Dickson press, from the name of its inventor, depends for its action on the friction caused by the pressure of the briquettes on the walls of the tube. It is found that a pressure of 8 tons per square inch is required to force the column of finished briquettes along the tube against the frictional resistance only, and this is sufficient to make a dense and well-finished briquette.

Considerable power is expended in the operation, and the tube becomes heated by the friction; but this is an advantage within limits, as the heat causes the surface of the briquettes to become tarry, which adds greatly to their damp-resisting properties and cohesion. The tubes are often water-jacketed, to prevent too great a rise of temperature, as the punches work continuously at the rate of 50 to 60 strokes per minute.

Much of the mechanical treatment of the peat, such as triturating and briquetting, may be avoided by gasifying the air-dried sods in a producer and using the resultant gas for heating, steam raising, or driving explosion engines. Peat-gas is particularly suited for firing iron and steel furnaces on account of the very small amounts of sulphur and phosphorus present, and its use for this purpose in Sweden is one of the chief causes for the extreme purity of Swedish iron. Less steam is required in the producer than when anthracite or other dry fuel is used, because of the water already contained in the peat, and the resulting gas has a calorific value of about 150 British thermal units

to the cubic foot, or much the same as ordinary Dowson gas. The Merrifield plant used in Canada for the production of peat-gas consists of a pair of similar generators, one making "water-gas" and the other "producer-gas," these gases being mixed at the outlet to form the final product. The plant when worked with briquetted peat is claimed to yield 100,000 cubic feet of gas per ton at a cost of 1¼d. per 1,000 cubic feet, reckoning fuel at 6s. per ton and labor at 10d. per hour.

For the utilization of peat on a commercial scale some more efficient way of harvesting it than the usual method of digging it by hand from the bog is essential. The means adopted will depend to a great extent on the comparative dryness and solidity of the bog. In some cases, much of the water can be drained away previously to attempting to remove the peat; but if that is impossible owing to the formation of the land, a dredger, similar to those used for harbor work, is floated on the surface and delivers peat, in the form of mud, to barges in attendance. An aerial ropeway forms a convenient system of transport from the barges to *terra firma*. In the cases of fairly dry bogs the surface is cleared of growing moss, stumps of trees, etc., which will serve as fuel for the drying plant. In some of the Canadian bogs portable tramways are laid on the top of the bog to convey the peat to the works. The surface of the bog is then harrowed, and when the loosened peat has become fairly dry by the action of wind and sun, it is raked together, loaded into trucks, and hauled to the briquetting works. At other bogs mechanical dredgers running on broad wheels are employed. An endless chain, fitted with alternate knives and scraping-plates, works along the face of a trench about 4 feet deep. The peat sliced off is raised to the top of the machine and deposited onto a conveyor, which delivers it into a casing containing a rapidly-revolving paddle-wheel. The blades of the latter drive the peat out in a continuous shower, which falls on the ground 10 or 15 yards away. The layer thus formed is about ½ inch thick, and soon becomes fairly dry, when it is raked up and taken to the works.—Engineering.

LODGE'S FOG-DISPELLING APPARATUS.

SIR OLIVER J. LODGE has been granted patents in most countries entitled "Improvements in means for the production of continuous high potential electrical discharges applicable for the deposition of dust, fume, smoke, fog and mist, for the production of rain and for other purposes," of which the following is an abstract:

The property of the electric discharge of causing the coalescent deposit of matters suspended in a gaseous medium has not come into practical use on account of the difficulties attendant on the use of the statical electrical apparatus, this class of apparatus being too delicate and easily upset for use on an extensive scale. Sir Oliver Lodge's invention consists in a combination of high potential rectifiers, arranged in quadrilateral groups of four or multiples of four in such a way that instead of the reverse pulses of the alternating-current supply being suppressed or non-existent as at present they are redressed to form the positive and negative discharging streams required for the deposit purposes.

Referring to the accompanying drawings: Fig. 1 is a diagrammatic view showing one method of carrying the invention into effect; Fig. 2 shows diagrammatically another method in which an alternating-current dynamo is used; Fig. 3 is a view of a rectifier suitable for use in carrying out the invention; while Figs. 4 and 5 show some of the means of insulation which may be employed.

In the arrangement shown in Fig. 1, *a* is a battery in circuit with an intermitter, *b*, and the primary, *d*, of a large Ruhmkorff induction coil; a condenser, *c*, may be placed in parallel with the intermitter, *b*. The secondary *e* of the Ruhmkorff coil is connected through two series of high potential rectifiers, *f g*, preferably of the form hereinafter described, to the terminals *k m* of the insulated coatings of a pair of Leyden jars, whose outer coatings, *j l*, are in electrical connection. To the terminals *k m* are also attached the leads for discharging wires, *o p*, which are supported by insulators, *n*. A dynamo may be employed in place of the battery. The leads or discharging wires must be well insulated (see Figs. 4 and 5). The dischargers may be points, flames or other means whereby a free discharge can be obtained; parallel rows of barbed wire or of barbed-wire fencing or other metallic areas may be used, one of which areas may be insulated while the other is earthed, or both may be insulated and placed facing each other beyond sparking distance in the place where the discharge is wanted. When the apparatus is used for the removal of smoke or the like, it is preferable to insulate both dischargers; when electrification of clouds is the object, one set of dischargers would usually be earthed, and the other set arranged so as to be discharged skyward by well-insulated conductors.

In the operation of the apparatus the current generated in the battery or dynamo is interrupted by the intermitter and induces intermittent pulses of violently high potential in the secondary coil of the Ruhmkorff coil; these pulses are transmitted through the rectifiers, positive pulses through the series *f* and negative pulses through the series *g*, to the insulated coats of the two Leyden jars. The object of each series of rectifiers is to transmit a current easily in one direction and to strongly oppose a passage of current in the opposite direction; by this means the intermittent supply from the induction coil is enabled to maintain the jar or jars steadily charged. The higher the potential desired the more numerous are the rectifiers required in each series, and it has been found that three in each series is a convenient number to use where it is required to keep up a practically continuous discharge, between the dischargers, at a potential of about a quarter of a million volts.

Fig. 2 shows an arrangement in which the source of current is an alternating-current dynamo; the dynamo 1 is placed in circuit with a condenser, 2, and

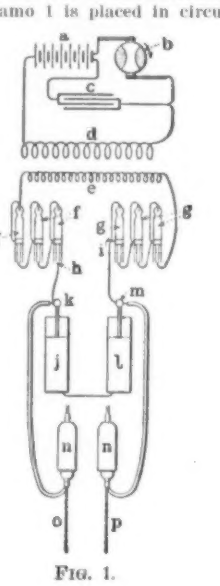


FIG. 1.

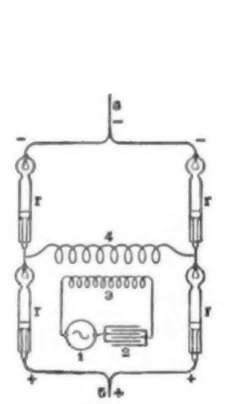


FIG. 2.

the primary, 3, of an alternating-current transformer which may in this case have a closed magnetic circuit. The high-potential rectifiers *r*, arranged in a quadrilateral, are combined in four groups, each of which contains one or more rectifiers in series, the number depending on the potential required. Two of the groups of rectifiers similarly directed are connected between the terminals of the secondary coil 4, and the positive discharging means, 5, and the other two, both directed in the opposite direction, are connected between the terminals of the coil 4 and the negative discharging means, 6. In this arrangement an alternating-current dynamo may be used, having an excessively high frequency, say, 3,000 to 4,000 alternations per second, or the alternating discharge of condensers such as Leyden jars may be employed.

In this case, as in the arrangement shown in Fig. 1, Leyden jars may be connected between the rectifiers and discharging means, thereby obtaining a more continuous discharge.

The rectifier shown in Fig. 3 is similar to the Cooper Hewitt mercury-vapor lamps, and is formed from thick glass tube, 8, having an iron anode, 9, at the top and provided at the bottom with a mercury-pool cathode, 10, surrounded by an outside metallic band, 11; the positive terminal, 12, is formed on this band, which is connected to the anode, 9, by an insulated wire, 13, the contact being made by placing the end of the wire, 13, in a vessel, 14, containing mercury formed at the top of the tube, 8. A U-tube, 15, containing mercury is placed so that the contact leading from the mercury pool is under the surface of the mercury in the U-tube, as is also the end of the wire, 16, leading from the cathode. The object of the mercury contacts, 14 and 15, is to avoid the loss which would otherwise occur at the exposed points on the conductors, when used to convey electricity at the high potential necessary. In some cases the rectifiers may be submerged in oil in order to lessen the liability to loss and spitting off, but this is not usually found to be necessary.

In Fig. 4 the conductor 22 is supported on an ebonite or glass or earthenware rod or other suitable insul-

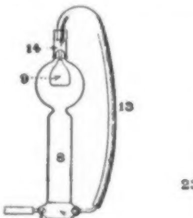


FIG. 3.

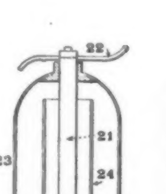


FIG. 4.

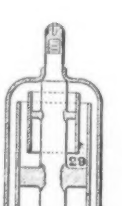


FIG. 5.

ator, 21, from a supporting beam, 20; the rod is protected by two umbrella-shaped inverted covers, 23 and 25, and a cylindrical vessel, 24, open at the top, all of which are constructed of ebonite, earthenware, glass, mica or other suitable material. Fig. 5 shows a modification in which the conductor is suspended from a rod, 27, protected by cylindrical vessels, 28, 29, all being constructed of suitable insulating material.

The apparatus described may also be used for causing the deposit of lead fume in the manufacture of white lead by furnace processes or for depositing valuable factory dust.

The principal claims are:

(1) The method of causing small particles to coalesce into larger ones by the use of a high potential discharge, the supply of electricity being obtained from a dynamo or battery or from the alternating discharge of condensers. (2) The method of causing small particles to coalesce into larger ones by the use of a high potential discharge obtained by the use of high potential mercury rectifiers and a high potential intermittent or alternating electric current. (3) The method of producing a continuous high potential discharge of electricity in one direction by the use of high potential mercury rectifiers so arranged as to transmit pulses always in one direction and so to charge and keep charged condensers which are connected to the discharging means, substantially as described.

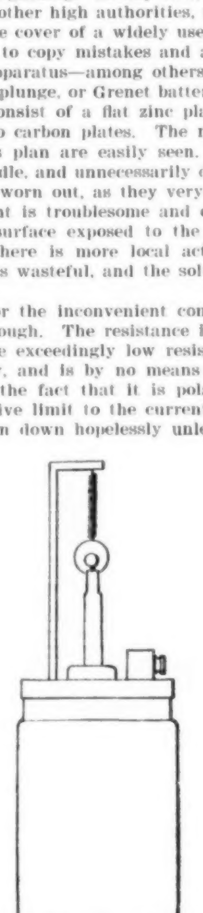
A NEW FORM OF CELL.

By WALTER P. WHITE, Carnegie Institution Geophysical Laboratory, Washington, D. C.

THE story is tolerably well known of the diagram of an impossible iceberg, published some years ago in a text-book of high rank. It may have been a rational diagram, shortened to save space, or an out-and-out blunder in the beginning. At any rate, it was unthinkingly copied by other high authorities, until it attained a position on the cover of a widely used work.

The tendency to copy mistakes and anachronisms is often seen in apparatus—among others, in the case of the bichromate, plunge, or Grenet batteries. These batteries usually consist of a flat zinc plate, set between and close to two carbon plates. The numerous disadvantages of this plan are easily seen. The zincs are awkward to handle, and unnecessarily difficult to amalgamate. When worn out, as they very frequently are, their replacement is troublesome and expensive. And especially, the surface exposed to the solution is too large, so that there is more local action than there need be. This is wasteful, and the solution needs frequent renewal.

The reason for the inconvenient construction is, of course, plain enough. The resistance is thereby made very small. The exceedingly low resistance, however, is not necessary, and is by no means worth its cost. This is due to the fact that it is polarization which forms the effective limit to the current in these cells. The cell will run down hopelessly unless the external



A NEW FORM OF CELL.

resistance is so high that the very low internal resistance becomes a matter of no consequence.

It follows that these frail, troublesome and expensive batteries are in every way inferior to the ordinary carbon cell, when it is supplied with amalgamated zinc and chromic acid solution. The zincs are easy to amalgamate and keep clean, and can be replaced in any town at nominal cost. The solution lasts much longer, and is protected from dust and evaporation. This form of bichromate battery has only one serious disadvantage. The acid solution often corrodes the binding post which is clamped on the carbon. This trouble can be prevented by a small, very thin washer of gold or platinum. It is equally likely to occur with other forms of bichromate battery, where the surface to be protected from the acid is greater.

The idea of filling a carbon cell with bichromate solution is not new, though its value seems still to need pointing out. The chief object of the present article, however, is to call attention to a device for supporting the zinc in such cells. This is shown in the figure. A rod is fixed in the carbon, and the zinc is attached to this by an insulating support and a spiral spring. The zinc in such a battery can be used as a key to close the circuit, and is drawn up by the spring when the current is no longer needed. The zinc is thus exposed to the wasteful action of the strong acid only for the actual time of taxing current, and in particular is not likely to be left in the solution for long periods through forgetfulness. The average life of a charge of acid and zinc is so much increased as to make a very great difference in the value of this type of cell to a busy teacher or laboratory assistant. The quickness with which the zinc is raised and lowered, and the fact that it can be done with one hand, where the usual plunge battery requires two, make this form of cell very convenient, especially for class demonstration. When more than one cell is to be used at a time they can all be worked in unison by running a wooden rod

through the rings by which the springs are attached to the zincs.

Cells of the type here described are, perhaps, even more valuable in the laboratory than in the lecture room. For fairly strong currents they are about as steady as copper sulphate batteries, and enormously cheaper and less troublesome, and wherever the extreme steadiness of the storage or Edison battery is not demanded their convenience and low cost of maintenance have made them, in the writer's opinion and experience, the best battery for most high-school laboratory work.—School Science and Mathematics.

HOW TO MAKE A HYDROMETER.*

By EDWARD F. CHANDLER.

IT seems quite appropriate to open an article on the hydrometer with a few brief statements concerning specific gravity.

By specific gravity (sp. gr.) is meant the relative weight of equal volumes of bodies, assumed to be under like conditions of temperature and pressure. For the purpose of comparing the weights of equal volumes of different bodies, they are all referred to an assumed standard. The standard for liquids and solids is pure water weighed at a temperature of 4 deg. C. (39 deg. F.), the temperature at which it possesses the greatest density, or specific gravity.

The specific gravity of solids may be determined by first weighing the body in air, and then in water at the required temperature. This is done by suspending the body from one of the arms of a balance, by a thread or wire. To weigh in water it is necessary only to place a vessel of water so that the suspended body may hang in the water or float upon it. A body which sinks in water displaces a volume of water equal to its own, and loses a weight just equal to the weight of the water displaced. The loss in the weight of the body when weighed in water will, therefore, be the weight of its own volume of water. By dividing the weight of the body in air by the loss of weight in water, the specific gravity is obtained. When the body whose specific gravity is sought will not sink, we may attach a sinker, which must be allowed for when computing the specific gravity, and if the specific gravity of a substance is required, which is soluble in water, a liquid of known specific gravity in which it is not soluble may be used. The specific gravity of powder is obtained by partly filling a small flask with it and weighing both, the weight of the empty flask, as well as the water it will contain, having been previously ascertained. The flask is next weighed, filled with pure water. The difference between the last weight and the first will be the weight of the water in the flask. The difference between this weight and the weight of the water the flask will contain when full will give the weight of water displaced by the powder, from which the specific gravity may be determined.

The specific gravity of liquids is obtained by means of the specific gravity flask, made to contain a certain number of grains or grammes of water at a temperature of 60 deg. F., its capacity being marked upon it. To take the specific gravity of a liquid, it is necessary only to weigh the flask, filled with the liquid in question brought to the requisite temperature, deduct the weight of the flask, and divide by the marked contents of the flask. This is a very accurate method of determining the specific gravity of liquids, but it requires a very sensitive balance and delicate handling, and for practical purposes a hydrometer is generally used.

To take the specific gravity with a hydrometer, it is only necessary to place the instrument in the liquid and read the graduation upon the stem to which the instrument sinks. Figs. 1 and 2 show two of the most general forms of the standard hydrometer. The construction of the instrument is such that the weight is below the air chamber, making the center of gravity very low and causing the tube to assume a perpendicular position when floating. Hydrometers are constructed for liquids lighter than water and for liquids heavier than water.

Various methods of graduation are resorted to. Baumé's scale is quite generally used. For want of space, I would refer my reader to any one of the numerous textbooks upon physics, wherein a most elaborate description of hydrometer scales and tables may be found. It is my intention merely to introduce the subject, so that the following description of my hydrometers (or hydroscopes) will be as clear as possible.

Keeping in view the fact that for heavy liquids the zero point is at the top of the scale and for light liquids the zero is at the lower part of the stem, it will be seen that, as the liquid (see Fig. 3) becomes more dense the instrument will rise, whereas in the case of Fig. 4, as the liquid becomes less dense the hydrometer will sink.

Referring again to Figs. 3 and 4, we notice that the hydrometers shown are made from test tubes, which are very easily obtained, and any one desiring to experiment along this line may find the following interesting: Take a six-inch test tube, and weigh it by placing in it some fine shot and sealing wax until you have found a point quite near the top, which you wish to call the zero, as in Fig. 3. A blank slip of paper should have been previously placed in the tube, so as not to change the weight or poise, as would be the case if it was to have been added after the amount of shot had been decided upon. This blank slip of paper is to be graduated in any convenient way that may suit the case at hand; for instance, the photographer might find such an instrument of considerable value if only possessing one mark, at a point found when standing in a solution of known quality or strength. The shot and sealing wax will, when gently heated, form a solid mass, which will adhere to the bottom of the tube. Fig. 4 is constructed in the same simple manner, except that less shot is used, just enough being added to cause the tube to float erect in the solution.

In Fig. 5 we have an instrument most readily con-

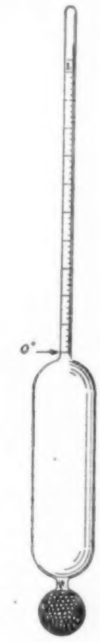


FIG. 1.

FIG. 2.

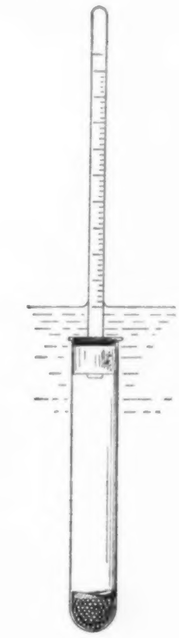


FIG. 5.

structed by the amateur, which quite closely resembles the standard hydrometer. Here we have the test tube and shot and a cork inserted in the mouth of the tube bearing a light glass tube in which has been placed the paper graduated to meet the demands of the maker. The stem or light glass tube is left open, and a little longer than required, so that when the last shot has been dropped in and the scale adjusted to its place, the top may be sealed over in the alcoholic lamp or gas flame. The cork which holds the stem is pushed down about 1-16 inch and paraffin should be poured around the mouth of the tube to insure a close and air-tight seal. This style of instrument may be constructed for light or heavy liquids as the case may be. As simple as the construction of these instruments is, they would be accurate enough for many practical purposes, especially when a great variety of solutions are maintained, and it would be desirable to keep one constantly in the bath. One of these instruments would prove quite valuable in the kitchen, used as a lactometer or a milk gage, using as a standard some milk which you have reason to believe is of desirable quality; and having fixed the point at which it floats in this instance, we only have to place the tube in the suspected solution, whereupon, if it is constructed like Fig. 3, it will rise in proportion to the quantity of water present. The quantity of water, viewed from a hygienic standpoint,

FIG. 3.

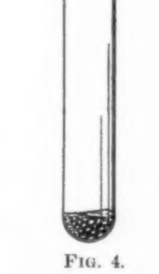


FIG. 4.

is not necessarily harmful, but the small amount of milk as compared with the water is sometimes alarming.

A small party of antiquarians who have been carrying out excavation operations at Hierakonopolis, a spot some distance north of Assouan, which was the home of the earliest Egyptian kings, have returned to England with some interesting relics illustrative of the high degree to which civilization attained in Egypt thousands of years before the birth of the Christian era. The archeologists were successful in tracing the walls and houses and the disposition of the rooms dating from 3000 B. C. Vases of alabaster and granite and flint knives of delicate workmanship belonging to this period were also found.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

CONSTRUCTION OF LARGE TELESCOPE LENSES.*

By DR. C. FAULHABER.

THE three principal instruments for the study of the heavenly bodies are the telescope, the spectroscope, and the photographic camera; and since the two latter are made useful only as they are attached to the former, it is the telescope which we must still regard as the key to unlock the doors of the universe. Readers have all doubtless seen a large telescope, and many have had an opportunity of looking through one, for most observatories reserve certain hours for the public. Accordingly a description of the instrument as a whole may be omitted, and we will merely recall that, notwithstanding it is so long and heavy, complicated mechanical and electrical means are provided for pointing and accurately guiding the telescope, so that it follows automatically the motion of any chosen celestial object. But no less hard than the difficulty of providing these mechanical adjuncts is the optical problem of providing the great double lens called the objective at the upper end of the tube. The objective is the fundamental part of the telescope, on whose excellence the value of the whole instrument depends, and not only its quality but its size also is of the highest importance to make possible the observation of objects otherwise forever invisible. Hence it is that telescopes are designated, not by the maximum magnification which they can produce, nor by their length, but rather by the diameter of their objectives. Thus one speaks of the 40-inch of the Yerkes Observatory, the 36-inch of the Lick Observatory, and the 32-inch Potsdam refractor.

In order to study the construction of a great telescope objective, the attention of the reader is now invited to a great optical glass works, of which there are but three principal ones in the world, namely, those of Schott & Genossen, in Jena; Mantois, in Paris; and Chance Brothers & Co., in Birmingham.

To begin the process of construction a crucible of fire-proof clay, which already has been warmed gradually for several days, is placed within a melting oven of peculiar construction. This oven is then closed and slowly heated to white heat, while at the same time the materials to compose the glass are admitted to the melting pot through a peephole about as large as a man's head in the wall of the oven.

The material varies with the kind of glass to be made. Until the beginning of the year 1880 only two kinds of optical glass were in use, of which one—the so-called crown glass—was composed of quartz sand, potash, soda, and calcspar, and the other—the so-called flint glass—was composed of quartz sand, potash, and lead oxide. There are now more than one hundred varieties of optical glass produced by the intermixture of other materials, such as phosphorus, boric acid, magnesium, zinc, barium, antimony, which are distinguished by different properties of dispersion and refraction. The choice of the proper glass for the two lenses depends on the purpose which the telescope is to serve, and particularly whether it is to be employed for visual or photographic observations.

About thirty hours is consumed in the introduction of the materials. If there be no mishap—for sometimes at the temperature of 1,600 deg. to 1,800 deg. the melting pot cracks or even the stones of the oven burst—the impurities are then skimmed off from the surface, and for about fifteen hours the mixture is stirred by means of a hook-shaped, white-hot clay cylinder.

When the ingredients of the glass are melted they have a tendency to separate in layers according to their specific gravities, and thus to destroy the homogeneity required for optical purposes. This difficulty is chiefly overcome by the continuous stirring of the melted mixture. By repeated tests the moment is at length found when the charge assumes the proper color and degree of fluidity. When this moment arrives the farther side of the oven is opened and a two-wheeled truck with long handles is backed up to the opening. Two projecting pieces of the truck reach out under a ring which is made for this purpose on the clay melting pot, and the latter is carefully lifted from the floor of the oven. On account of the overflow of melted glass, which often cements the pot to the bottom of the oven, this is an operation involving a great risk that the fragile white-hot clay melting pot may break, owing to the shaking required to free it from the oven.

The melting pot is next moved over to a great circular iron mold, and is then set down upon the floor, in order to reinforce the pot with an iron band. On opposite sides of the iron band are steel pins fitting on hooks attached to the truck. By means of this arrangement the pot is lifted above the mold and its contents poured therein. Contrary to what might perhaps be expected, this process is accomplished with little noise beyond a slight crackling and rustling sound. This is the culminating point in the whole process of glass making, and gives rise not only among unaccustomed onlookers, but also among the skilled workers themselves to mingled feelings of great anxiety and exalted admiration.

The mold with its fiery contents is then covered with an iron plate and pushed over to the cooling oven, which has in the meanwhile been carefully heated and opened ready to receive the charge. Here the mold is lifted by a tackle and thrust into the cooling oven, where, after the walls have been sealed up as tightly as possible, it remains from four to six weeks undisturbed. Very gradual lowering of the temperature is required, else the cooled mass might burst with the slightest touch, or at least show prejudicial strains in the interior.

When at length the oven is opened the mold is found

* Translated from Prometheus and published in Annual Report of Smithsonian Institution.

to contain a solid, feebly lustrous, milk-white plate, which is easily removed from its iron bed.

There now begins a week-long process of grinding and polishing of the glass plate preparatory to a preliminary examination as to its freedom from striæ, bubbles, and conditions of interior strain. Experience shows that in general only a part of such a plate is of optical value. This part is cut out by means of a glass saw and again heated till soft in a crucible, which corresponds approximately with the final form of the objective. After this comes a second gradual cooling during a period of several weeks and another rough polishing and testing of the quality of the resulting plate of glass.

In favorable cases the product is now ready for removal to the optical shop, but commonly there are ten or more unfavorable trials before securing a successful result in the manufacture of a disk of glass for a lens of one meter diameter. Since, as you know, there are two such disks of equal size required for a telescope objective, weeks and months of further work are required for the production of the second. The process is in all respects the same, except that somewhat different materials are employed for the mixture, corresponding to the differences in optical properties desired. In outward appearance crown and flint lenses do not differ much, but one is somewhat heavier than the other.

The description just given relates to the most modern methods of glass making as they would now be pursued at Jena in the manufacture of glass disks for a telescope of 1.25 meters aperture. In the older processes it was customary to melt a charge about three times as large as required, and after this had reached the proper color and consistency, to allow the melting oven to cool slowly and thus to take the place of the special cooling oven. On opening the oven the glass block would be found broken in several pieces, and if there was none among these which would answer the purpose the process would then be repeated. When a rough block of suitable size and quality was obtained it was put in a crucible of about the proper lens form. The whole was then again melted and cooled and then polished for testing. As an example of the cost in time spent in this procedure, it will be recalled that the Paris glass works required four years for the production of the two lenses of the 36-inch Lick objective. The melting was done twenty times, and each time a month was spent in the cooling. On the other hand, the Jena glass works, employing the improved processes, prepared both disks of the slightly smaller Potsdam 80-centimeter objective in a few months.

It may be of interest to rehearse briefly the story of the rapid development of the industry of optical glass making in Germany, principally during the last ten years.

The pioneer in the production of glass for astronomical purposes, according to purely scientific methods, was the renowned Joseph von Fraunhofer, of Munich (1787-1826). But it is only twenty years since Prof. Abbe and the glass manufacturer, Dr. Schott, of Jena, took up the work where Fraunhofer laid it down, and succeeded in replacing the old flint and crown glasses by new varieties of glass, by means of which the chromatic differences of spherical aberration are nearly eliminated. The production of the new glasses on a commercial scale began in the autumn of 1884. In order to support the very costly preliminary experiments, the Prussian government made considerable grants of money in consideration of the national value of the work. This governmental support was required but two years, for the undertaking progressed favorably and the productions found recognition almost immediately in the whole optical world, so that soon not only German, but foreign optical establishments, placed most of their orders for material in Jena. Not only are the common crown and flint glasses made here, but also a great number of improved crown and flint glasses, containing boric and phosphoric acids, to diminish the secondary spectrum on the one hand, and on the other containing metallic oxides, by means of which the dispersion and refraction may be increased or diminished. An extensive exhibition of these products was witnessed by the visitors who attended the Berlin Gewerbe-Ausstellung in 1896. There were shown disks for the construction of telescopic objectives of 110 and 125 centimeters diameter, and these were the largest pieces of optical glass which had then been made. Not only is optical glass produced for all kinds of instruments of precision, but also there is made at Jena glass tubing for physical, chemical, manufacturing, and medicinal purposes, and all sorts of chemical glassware, such as flasks, beakers, and retorts, besides cylinders for gas and petroleum lighting. There are now employed in this industry about 650 persons, and the value of the yearly output reaches 3,000,000 marks.

We are now prepared to detail to the further stages in the preparation of a great objective, and the attention of the reader is invited to the optical workshop. Here the glass disks are first ground and polished on both sides preparatory to a thorough testing. For this purpose there is a machine with a vertical spindle carrying an iron plate.

Upon this plate the glass disks are in their turn cemented with pitch, and above is a second iron plate, the grinder, provided with a spindle in the center. By means of this spindle the grinding plate is shoved hither and thither over the glass disk by machinery. The grinding material is emery powder and water. After the rough grinding is done the rough polishing on the same machine follows similarly, excepting that the grinding tool is replaced by a cloth-covered polishing tool, covered with rouge instead of emery.

After this preliminary work, a careful investigation of the disks is made in the laboratory by the aid of the microscope and polarization apparatus. If the objective is good it must appear bright in the polariscope, with the exception of being marked by a regular dark cross. If an irregular cross is seen, or, in certain conditions, brightly colored figures of various shapes, the disk must be returned to the glassworks to be remelted and cooled.

In case of a satisfactory outcome of these tests small pieces are cut off and prisms are prepared from them, whose refractive indices are determined by means of the spectrometer. Upon these measurements are based the accurate computation of the objective—that is to say, a tedious piece of work which requires repeated independent checking.

After this begins the real preparation of the objective lenses, one of which is to be ground concave, the other convex, on the same machine which was used in the rough grinding. This present procedure is similar to that already described, except that grinding tools opposite in curvature to the lenses and made of iron, brass, or glass are fed with finer and finer emery powder as the work approaches its finish.

Since everything depends on the proper guiding of the grinding tool to obtain the regular spherical surfaces, the operating of the machine demands great experience and care, and the work requires frequent testing by the application of the spherometer. When finally the right curvature is reached, after many days of work, repeated and accurate testing of the lens is made by the Toppler "Schlierenmethode" for small errors, nonhomogeneity, and other faults.

The fine-ground lens is now put upon a lathe and centered by means of a fine adjusting crane. This centering consists of shifting the lens about upon the spindle of the lathe until exact coincidence is reached between the optic axis (common axis of curvature of the two surfaces) and the mechanical axis of the spindle. Recognition of this condition depends on observing the reflections from the two glass surfaces, and accurate centering is reached when these reflections do not move with the rotation of the spindle. When the right adjustment is made the edge of the disk is turned off true by means of a grinding band fed with emery and water, and by this means the lens is reduced to the proper diameter.

After the centering follows the fine polishing on a special polishing machine. The process is much the same as that of rough polishing, excepting that instead of a cloth-covered tool there is provided for each face a series of great pitch-covered plates. Frequent trials of the surfaces are made by means of so-called "test glasses." These are small glass plates ground and polished accurately to fit the desired curve; that is to say, convex for a concave surface, and *vice versa*. Their employment in testing depends on the following principle: If two closely fitting polished surfaces are laid one upon the other there is retained between them a thin film of air which exhibits the so-called "Newton's colors," seen in soap bubbles and similar thin transparent structures. The color is the same over the whole surface only when the thickness of the inclosed film is everywhere uniform, which only occurs when the lens has the same curvature as the test glass. At the beginning of the polishing the Newton's colors appear as rings of more or less width. By the proper use of polishing tools of different sizes, and by suitable regulation of the stroke and velocity of the machine, the condition is finally reached when a uniform color supersedes the rings, no matter where the test glass is laid upon the lens. By such methods of measurement in terms of the wave length of light, deviations of thickness of only one ten-thousandth millimeter (one two-hundred-and-fifty-thousandth inch) can be accurately detected, a magnitude scarcely appreciable to the lay mind. It is obvious that the fine polishing in such conditions is an exceptionally difficult task, the more so that care must always be exercised to avoid all blemishes on the surfaces, such as scratches and the like, and only the most competent and experienced workers can succeed with it. A conception of the difficulties to be overcome may be found when it is said that the fine polishing of a single lens surface takes several months.

When both lenses have passed through the processes of fine grinding and polishing they are inserted in brass or iron mountings which have meanwhile been prepared for them and in which they lie separated by a small free space. Cementing together with Canada balsam or turpentine, as generally practised with small lenses, and formerly with large ones also, has more recently been discontinued on account of the difficulty of separating large cemented lenses for subsequent cleaning.

After the lenses have been placed in their cell there remains only the final testing in the telescope tube itself. I shall not describe the complicated centering apparatus employed in this test. The errors of an objective and their causes are numerous, and their discovery and correction demand great experience and skill.

In conclusion, we may inquire where the telescopes of largest objectives are located, and by whom they were made. In the first place, there is the objective made for the Paris Exposition of 1900, but not among the telescopes in present use. It is 1.24 meters in diameter, and the glass alone weighs 580 kilogrammes. The cost of the two lenses was 75,000 francs. These disks were poured by Mantois and ground by Martins, both of Paris. Up to the present time the objective has not been usefully employed. The second and third places, as regards size alone, are taken by the objective of the Yerkes Observatory, near Chicago (1897), and that of the Lick Observatory, at Mount Hamilton, Cal., with diameters, respectively, of 105 and 91 centimeters. Both were poured at the Paris glass works and figured by Alvan Clark in Cambridgeport, Mass.

They are both satisfactory, though not prepared entirely on the basis of computation, but rather by repeated trials, and brought to their completion by the so-called method of local correction. After them in size comes the great refractor of the Potsdam Observatory, prepared solely for celestial photography and having a diameter of 80 centimeters. This objective was poured in Jena and figured at the optical works of C. A. Steinheil Söhne, in Munich, in 1899. It is recognized to be of the highest order of merit, and is a strong testimony to the ability of German manufacturers in this line. The Potsdam refractor has, in addition to the 80-centimeter photographic lens, a second visual lens of 50 centimeters diameter, and being thus a double refractor is perhaps the largest astronomical instrument in use in the world. Both of the great American telescopes are devised solely for visual purposes, and can only be used for photography by the aid of auxiliary lenses which cut off some of the light.*

Among other large objectives may be enumerated the Pulkova refractor, at St. Petersburg, by Clark, diameter 76 centimeters; objective of the Observatory of Nice, of equal diameter, by Henry Brothers, of Paris; the objective of the Vienna Observatory, of 71 centimeters aperture, by Martins, and the Treptower objective, of 70 centimeters aperture, poured at Jena, ground in Munich (1896), and costing 55,000 marks.

The objective of the Dorpat refractor, with 25 centimeters aperture, which, as it came from the master hand of Fraunhofer, was regarded as a wonder of the world, can scarcely be counted among the large telescopes to-day, for already more than 100 exceed its dimensions. It would lead too far to mention them all, but it is not out of place to remark that there is work of great value also for the smaller lenses. Interesting studies of the features of the planets have been made even in recent times with smaller instruments. Thus Schiaparelli, the famous discoverer of the so-called Martian canals, made his earlier valuable observations with an 8-inch telescope, which would now be classed as a minor instrument. In planetary observation the advantages of fine optical definition, together with good atmospheric conditions, combined with practised eyes, are of more consequence than high power or great light-gathering capacity. The advantages of the largest instruments lie in the possibilities they afford of observing the fainter fixed stars and nebulæ which lie at immeasurable distances.

THE VELOCITY OF LIGHT.

DATA for the velocity of light, verified by independent astronomical observations, were well known prior to the century; for Römer had worked as long ago as 1675, and Bradley in 1727. It remained to actually measure this enormous velocity in the laboratory, apparently an extraordinary feat, but accomplished simultaneously by Fizeau (1849) and by the aid of Wheatstone's revolving mirror (1834) by Foucault (1849, 1850, 1862). Since that time precision has been given to this important constant by Cornu (1871, 1873, 1874), Forbes and Young (1882), Michelson (1878, et seq.), and Newcomb (1885). Foucault (1850), and more accurately Michelson (1884), determined the variation of velocity with the medium and wave length, thus assuring to the undulatory theory its ultimate triumph. Grave concern, however, still exists, inasmuch as Michelson and Morley (1886) by the most refined measurement, and differing from the older observations of Fizeau (1851, 1859), were unable to detect the optical effect of the relative motion of the atmosphere and the luminiferous ether predicted by theory.

Römer's observation may in some degree be considered as an anticipation of the principle first clearly stated by Döppler (1842), which has since become invaluable in spectroscopy. Estimates of the density of the luminiferous ether have been published, in particular by Kelvin (1854).

THE HISTORY OF SPECTROSCOPY.

CURIOUSLY, the acumen of Newton (1666, 1704) stopped short of the ultimate conditions of purity of spectrum. It was left to Wollaston (1802), about one hundred years later, to introduce the slit and observe the dark lines of the solar spectrum. Fraunhofer (1814, 1815, 1823) mapped them out carefully and insisted on their solar origin. Brewster (1833, 1834), who afterward (1860) published a map of 3,000 lines, was the first to lay stress on the occurrence of absorption, believing it to be atmospheric. Forbes (1836) gave even greater definiteness to absorption by referring it to solar origin. Foucault (1849) pointed out the coincidence of the sodium lines with the D group of Fraunhofer, and discovered the reversing effect of sodium vapor. A statement of the parallelism of emission and absorption came from Angström (1855) and with greater definiteness and ingenious experiments from Stewart (1860). Nevertheless, it was reserved to Kirchhoff and Bunsen (1860, 1861) to give the clear-cut distinctions between the continuous spectra and the characteristically fixed bright-line or dark-line spectra upon which spectrum analysis depends. Kirchhoff's law was announced in 1861 and the same year brought his map of the solar spectrum and a discussion of the chemical composition of the sun. Huggins (1864, et seq.), Angström (1868), Thalén (1875), fol-

* The Yerkes telescope is used as a photographic instrument by interposing in front of the plate a color screen for removing the violet rays and exposing plates sensitive to the yellow rays.

lowed with improved observations on the distribution and wave-length of the solar lines; but the work of these and other observers was suddenly overshadowed by the marvelous possibilities of the Rowland concave grating (1882, et seq.). Rowland's maps and tables of the solar spectrum as they appeared in 1887, 1889, et seq., his summary of the elements contained in the sun (1891), each marked a definite stage of advance of the subject. Mitscherlich (1862, 1863) probably was the first to recognize the banded or channeled spectra of compound bodies. Balmer (1885) constructed a valuable equation for recognizing the distribution of single types of lines. Kayser and Runge (1887, et seq.) successfully analyzed the structure of the spectra of alkaline and other elements.

The modernized theory of the grating had been given by Rayleigh in 1874 and was extended to the concave grating by Rowland (1892, 1893) and others. A general theory of the resolving power of prismatic systems is also due to Rayleigh (1879, 1880) and another to Thollon (1881).

The work of Rowland for the visible spectrum was ably paralleled by Langley's investigations (1883, et seq.) of the infrared, dating from the invention of the bolometer (1881). Superseding the work of earlier investigators like Fizeau and Foucault (1878) and others, Langley extended the spectrum with detailed accuracy to over eight times its visible length. The solar and the lunar spectrum, the radiations of incandescent and of hot bodies, were all specified absolutely and with precision. With artificial spectra Rubens (1892, 1899) has since gone further, reaching the longest heat waves known.

A similarly remarkable extension was added for the ultra-violet by Schumann (1890, 1892), contending successfully with the gradually increasing opacity of all known media.

Experimentally the suggestion of the spectroheliograph by Lockyer (1868) and by Janssen (1868) and its brilliant achievement by Hale (1892) promise notable additions to our knowledge of solar activity.

Finally, the refractions of absorbing media have been of great importance in their bearing on theory. The peculiarities of metallic reflection were announced from his earlier experiments (1811) by Arago in 1817 and more fully investigated by Brewster (1815, 1830, 1831). F. Neumann (1832) and MacCullagh (1837) gave sharper statements to these phenomena. Equations were advanced by Cauchy (1836, et seq.) for isotropic bodies, and later with greater detail by Rayleigh (1872), Ketteler (1875, et seq.), Drude (1887, et seq.), and others. Jamin (1847, 1848) devised the first experiments of requisite precision and found them in close agreement with Cauchy's theory. Kundt (1888) more recently investigated the refraction of metallic prisms.

Anomalous dispersion was discovered by Christiansen in 1870, and studied by Kundt (1871, et seq.). Sellmeyer's (1872) powerful and flexible theory of dispersion was extended to include absorption effects by Helmholtz (1874), with greater detail by Ketteler (1879, et seq.), and from a different point of view by Kelvin (1885). The electromagnetic theory lends itself particularly well to the same phenomena, and Kolázek (1887, 1888), Goldhammer (1892), Helmholtz (1892), Drude (1893) and others instanced its adaptation with success.

ORIGIN AND CONTROL OF YELLOW FEVER.

By A. T. CUZNER, M.D.

THE first authoritative or authentic account of yellow fever comes from Bridgetown, Barbadoes, in 1647, where it was recognized as a pest (*nova pestis*) that was unaccountable in its origin, except that Ligon, the historian of the colony, on the spot connected it with the arrival of slave ships.

In tracing the disease down to the present time, one fact stands out prominently, namely:

PRIMAL CAUSE.

(1) That yellow fever in time and place has dogged the steps of the African slave trade, and

(2) The pure African negro has a very large racial immunity from yellow fever.

(3) When the negro of mixed blood has the disease, it is in a light form, and rarely fatal.

The filthy condition of a Guineaman on its arrival from Africa was a notorious fact, and the filth of that kind was discharged into the creeks and anchorages of slave ports in material quantity, year after year, for a long period.

Another point established by observation was that this fever was not present during any time of the voyage, but originated after the anchorage at the port of destination.

At Havana as many as a hundred slavers would arrive in one year.

Steady accretions of the filth of slave ships from the beginning of the traffic to America down to its abolition in 1808, and its final cessation previous to 1860, would account for a peculiarly pestiferous state of the harbor mud, of the beach, and even of the water; in fact, the water of the bay of Havana was pestiferous, and there was a standing order in the British navy against admitting it into ships.

Dr. Andouard, of Paris, was the first (1825) to generalize the facts and to deduce an hypothesis that has not as yet been proven false, viz., that typhus and yellow fever were filth diseases. Practical experience with both these diseases seems to verify his conclusions.

Gen. Benjamin Butler, by his sanitary measures, drove yellow fever from New Orleans, where it was endemic. Dr. Leonard Wood was able to drive it out of Cuba and Havana.

In the epidemic of 1888 in Jacksonville we were first employed by Mr. Henry l'Engle to superintend the cleaning up of the slums of East Jacksonville and Hansontown. We were afterward appointed a member of the Bureau of Medical Relief as aid to Dr. A. W. Knight.

We noticed in our medical experience, that those portions of the city in which we had worked as a sanitarian had the least fever record.

PROPAGATING CAUSE.

The latest investigation of this disease demonstrates that the mosquito (*Stegomyia fasciata*) is the main propagating cause.

The following, taken from the New York Medical Journal, will explain how the mosquito becomes the carrying agent of this disease. I have emphasized the last paragraph of Dr. Eberle because I believe that a greater stress will be placed upon the extermination of the mosquito, or screening against him, than in sanitary measures of precaution against the disease. These two measures must go hand in hand, but sanitation should be leader.

"During a term of service spent at various army posts in the Philippine Islands in the capacity of sanitary officer and surgeon, United States army, the subject of mosquito destruction and propagation became an interesting study to the writer.

"At the army posts of Jolo, from the number of admissions into the hospital of soldiers suffering from malaria and dengue fevers caused by the bites of mosquitoes, the subject of exterminating the pests became an important one.

"The walled city of Jolo has well-paved streets and is well drained with open cemented sewers. The streets are swept twice daily, the yards and alleys are cleaned, and all accumulation from kitchens and back yards daily carted away. No pools of water were allowed to exist, and no grass or weeds were permitted to grow in the public gardens.

"Every receptacle capable of holding water was removed and efforts were made to do away with all suspicious breeding places where mosquitoes might propagate.

"Yet with all these precautions to prevent their propagation, there were myriads of mosquitoes. It chanced one morning, as the writer hitched his horse to a papaya tree, he observed a knot hole on the trunk, of the tree full of water, and on close observation it was found that the water was alive with countless mosquito larvae.

"The writer carefully transferred the contents of the knot hole (consisting of about four ounces of water, sediment of decayed leaves and dirt) to a bottle, and taking this to the laboratory, the contents were emptied into a gallon glass jar, filled with distilled water, and covered over with two layers of mosquito bar.

"Next morning, on examining the jar, there could be seen numerous mosquito larvæ in all stages of development. Pupae were numerous, and twenty-five fully fledged mosquitoes, perched on bits of cork as resting places, were noticed. These newly-fledged mosquitoes were collected, chloroformed and classified with the aid of a powerful lens. Daily during the next ten days a new crop of mosquitoes was collected from the jar, and in all 500 were hatched from the contents of one knot hole.

"Three species of mosquitoes were noted and several varieties found of each of the species. *Culex*, or the common mosquito, predominated; next in number were the *Stegomyia fasciata*, or the yellow fever mosquito, and *Anopheles*, or the malaria-producing mosquito, came next.

"The second discovery in regard to the breeding places of mosquitoes came about in the following manner: One morning the writer noticed a branch which had recently fallen from a cocoanut tree, and on examining it, found where the stem becomes broad and concave at its point of attachment to the tree a mass of undisturbed black sediment. This was carefully gathered in a clean paper and taken to the hospital laboratory, where it was placed in a jar of distilled water. The next day newly hatched mosquito larvæ could be seen wriggling their way to the surface of the water. Daily examinations were made, and within ten days fully developed mosquitoes were collected and classified.

"A great majority of tropical trees have at the joining of each leaf with the tree concave depressions wherein mosquitoes breed and hatch safe from disturbance.

"Among the laity there is a widespread belief that the mosquito bite of itself causes the disease, and that the infection is from the mosquito *per se*. This is, no doubt, due to hearing the various species of mosquito classed as 'malaria mosquito,' 'yellow fever mosquito,' etc., but the fact is that the mosquito is merely the transferring agent, and must become infected itself before it can inoculate a human being with the disease. Some species are capable by their organism of carrying one disease, while others are limited to an entirely different one, each species spreading its own particular variety of infection. The bite of a mosquito of any species is innocuous, however, unless it has itself been previously infected.

"In view of this, it is the opinion of the writer that the only method of preventing the spread of transferable diseases is to teach the people to observe the strictest sanitation. Not only yellow fever, but many other transferable diseases, are filth diseases, and their micro-organisms spring, no doubt, from filth causes, but the contagion must be transferred to us through the mosquito which is so infected."

Hence, if absolute sanitation were observed, there would be no primary infecting of the mosquito.

Examples have come to my notice of cases of yellow fever being found even in the cold weather of November, which it would seem were beyond communication by means of the mosquito, but might have been prevented by careful sanitation and cleanliness.

The fact is, that this disease is endemic in certain semi-tropical countries where the population is concentrated and the filth is dense.

In the Isthmus of Panama we find yellow fever endemic, and this disease was doubtless conveyed thence to New Orleans.

Now, for all practical purposes we own Panama; it is a question for the government to eradicate this disease, not so much by fighting it when it makes its appearance sporadically in such localities as New Orleans or Pensacola, but by cutting off the supply of fever patients where the disease is endemic.

Other governments will follow in the wake of this, and yellow fever, like typhus, will be a disease of the past.

There can be no question but that this disease is steadily and unceasingly progressing toward extinction.

However, it will do no harm to destroy the *Stegomyia* and all his allies.

WHERE THE SEEDS ARE GROWN.

THERE are at the present time more than 600 seed farms in the United States—farms, that is to say, devoted to the production of vegetable, field crop and flower seeds to be sold to farmers and gardeners. Some of these plantations are very extensive, comprising as much as 1,000 acres.

Cabbage seeds are produced mainly in New York State, particularly on Long Island, and in Connecticut. Cucumber seeds come from Missouri, Wisconsin and Nebraska.

Corn and onions for seed are raised all over the country, and the same is true of melon seeds, but carrot seeds and lettuce seeds are mostly from the far West, California contributing the best and the greatest quantity.

Peas for seed are obtained from the neighborhood of Traverse, Mich., and Manitowoc, Wis., the output of that region being free from the little worms which are liable to infest peas grown elsewhere.

We send immense quantities of farm and garden seeds to Europe, but import only a few kinds, such as fancy grass seeds. Of clover and grass seeds we export hundreds of tons annually, Yankee clover being in especially great demand abroad.

Most of the red clover seed comes from the neighborhood of Toledo, Ohio, in which city is the principal market for that product. Nowadays clover seed is quoted as regularly as wheat and corn on the produce exchanges, and the same may be said of timothy seed.

Iowa alone produced more than two and a half million bushels of timothy seed last year, and during the same twelve months we exported more than $3,000,000 worth of grass and clover seed. These figures will give a notion of the magnitude of one branch of the seed-raising business. Utah is of all the States the greatest grower of the seeds of that wonderful forage plant alfalfa.

Onion seeds are gathered by going through the fields and cutting off the pods at the tops of the stalks, tying them in bundles and threshing them out on canvas. Beans are allowed to stand in the field until they are yellow, after which they are stacked up until perfectly dry and threshed out.

Peas are permitted to get dry and hard in the rows and then are taken to the barn for threshing. To get cabbage seeds, the stalks grown one year must be planted the next, when they run to seed. The same is true of carrots; the roots which have developed in one season are put into the ground the next and go to seed.

The harvesting of seeds is a business requiring no little expertness, most kinds being gathered when not all of the seeds are yet ripe, because otherwise many of them would be lost.

Melons, cucumbers, and tomatoes are crushed in a press and permitted to decay to some extent, the crude mass being finally thrown into water, when the pulp rises to the top, the seeds sinking to the bottom and being thus separated out. Seed-bearing stalks of cabbages and other vegetables are carried to the barn in sheets and there threshed out.

Tobacco seed is raised commercially in Virginia. The best is grown by the planters themselves and carefully saved from season to season, with a view to the perpetuation of valuable varieties.

This is the case not only in Virginia and Maryland, but also in Connecticut, where the most anxious care is exercised in the selection each season of the tobacco plants that are to yield seed for the following year.

To scientific methods adopted in seed growing is to be attributed much of the improvement accomplished in many economic plants, the most careful selections being made from year to year of the mother plants for the next crop. This is true not only of truck and field crops, but also of flowers.

It is in California that most of the flower seeds are produced, including the bulk of the petunias, verbenas, nasturtiums, and sweet peas.

In most European countries there are seed control stations, so called, at which seeds are tested by simple, yet interesting methods, the work of sprouting them being done mainly by young girls. There are forty such stations in Germany, where they have created

such a sentiment in favor of pure seeds, as opposed to the adulterated stuff, containing more or less weed seeds, commonly sold, that the best dealers are glad to submit samples of their merchandise for proof of quality, guarantees of which are returned by the stations after examination and trial.

The Department of Agriculture is anxious to establish a similar system of seed control in this country, if Congress can be persuaded to enact the requisite legislation.—New York Sun.

JELLY FISHES.

THE jelly fish is at home in the open ocean. The specimens which the seashore visitor sees are but wretched, battered wrecks of the storm, formless masses of soft jelly of which the sun and sand make short work. In its proper element—the open sea, with its stormless depths and sunny surface—the jelly fish is a marvel of beauty and complexity. It is not only a child of the sea, but a part of it—a mass of water

PELAGIA PANOPHYRA.

held loosely together by a few transparent gelatinous threads and membranes. It contains ninety-six per cent of water, yet its four per cent of solid matter is able, by convulsive contractions, to eject jets of water and thus to propel the frail, flower-like creature through the sea.

Although the domes, or bells, of some jelly fishes are more than five feet in diameter, they are so soft and weak that they cannot be pulled out of the water without tearing. Yet this soft transparent jelly is the seat of a complex and highly-developed animal life. The edge of the brightly-colored bell bears a ring of nerve centers and organs of sense—little eyes and ears—and, usually, a delicate fringe, each thread of which is both a long, flexible feeler and a weapon which exudes an irritant poison—as many a bather has learned from painful experience with these "sea-nettles." From the center of the bell hang appendages which resemble the pistils and stamens of a grotesque

THE "SOCIAL" PHYSOPHORA.

flower. These are the lips—eager, greedy lips, ever ready to seize tiny prey in shoals, and force it upward into the large and hungry stomach that lies hidden under the bell.

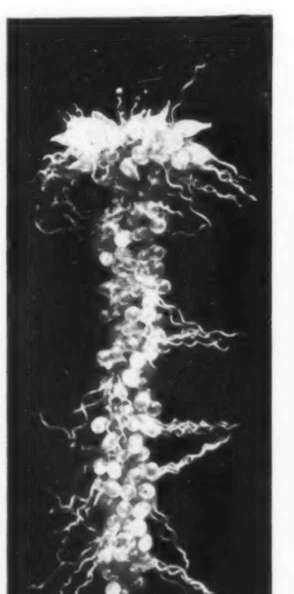
Of the remarkable photographs which are here reproduced, the first shows the "ear" jelly fish, common along the northern shores of Europe. In this species, four long lips, veined and curled like fern fronds, surround the hidden mouth. The "root-mouth" jelly fish is so called because it has, instead of one central mouth, a multitude of little mouths placed at the ends of its eight lip-like appendages. This species is often

THE "LANTERN" WHICH TAKES ROOT OR SWINGS AT WILL.

seen in immense shoals, gleaming blue, pink, or yellow on the sunlit surface of the sea. Piazzi Smyth, the English astronomer, once sailed through a shoal forty miles broad, near the Canary Islands. He estimated that the superficial layer alone contained 225,000,000 individuals, and it may be assumed that the stomach of each one contained at least a hundred thousand diatoms, the microscopic organisms that constitute the chief food of this species. At night these shoals of jelly fishes glow with a yellowish green phosphorescent light.

A MEDUSA.

Jelly fishes of the types which we have been considering—medusas they are often called—are even more curious in their origin and life history than in their structure and habits. They grow like flower buds on the stalk of a plant-like, motionless animal, a polyp, which is rooted to the sea-bottom. At a certain stage of their development these buds, or medusas, detach themselves from the parent stem and become independent, free-swimming animals. In the fullness of time they produce eggs, but these eggs hatch, not into free-swimming medusas, but into plant-like polyps, from which, in turn, new medusas spring.



A "SOCIAL" STEPHANOMIA.

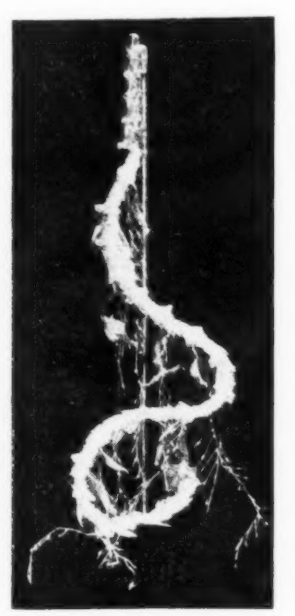
This is an example of what is called "alternation of generations," a phenomenon common in the vegetable as well as in the animal kingdom. Ferns, for instance, are propagated in a similar way.

In a few species the medusa itself develops a root-stalk, by which it attaches itself to rocks or plants temporarily and apparently at will. The "lantern" medusa is an example. In still other species this peculiar method of reproduction culminates in one of the marvels of zoological science. If we picture to ourselves a plant-like polyp developing simultaneously a great number of medusa-like buds which, instead of separating from the parent trunk, remain attached to it and, by the combined power of their myriad pumping bells, swim off, with it, we have an image of the "social" or tubular jelly fishes (*Siphonophora*). Such a creature may be regarded as a society, whose members are the medusa-like buds with which the stalk is studded. The stalk is a common artery, through which the vital fluids of all the members circulate and mingle together, a fact which makes possible the greatest marvel of all—the ingenious division of labor which has been established among the citizens of this mimic state. Some of the medusas do nothing

A SOCIAL FORM—PHYSALIA ARETHUSA.

but eat, eating for all and pouring the assimilated food into the common artery which conveys it to all the rest. Others have done away with their mouths and stomachs, and devote themselves exclusively to the convulsive pumping action by which the whole society is propelled through the water. Others have become feelers, or sense organs, and still others have degenerated into protective scales. Lastly, there is a set of reproductive buds, which may or may not detach themselves as free-swimming medusas.

In the physalias the stalk itself has been converted into a great swim-bladder, which gives some of these social forms a close external resemblance to the simple medusas first described. The singular form of one of these physaliæ suggested the fanciful name, "Portuguese man-of-war," by which it is called in old books. Its body, which is several inches long, is blue, while the crest is pink, and the tentacles crimson and purple. The animal has the power of elevating and depressing its crest and extending and contracting its



A "SOCIAL" STEPHANOMIA.

tentacles, some of which attain a length of several feet and are able to inflict painful stings. Many other jelly fishes are equally gorgeous in coloring.

In the species first mentioned, in which a plant-like polyp throws off free-swimming generative buds, or medusas, the latter sometimes attain dimensions mon-

strously disproportionate to those of the parent stalk. A certain medusa, or "sea blubber," of which specimens are found seven feet in diameter, with tentacles fifty feet long, is known to be the bud of a polyp only half an inch in height, and similar tiny polyps develop from the eggs of this gelatinous giant of the sea. Contact with the tentacles of some of these creatures produces a very painful irritation, which sometimes continues for months and affects the heart, lungs and entire nervous system.—Adapted from Wilhelm Boelsche in Die Woche.

THE AGRICULTURAL APPLICATION OF THE GASOLINE AUTOMOBILE.

By the English Correspondent of SCIENTIFIC AMERICAN.

DURING the past few months the application of the gasoline motor vehicle for diverse agricultural purposes has been developed in England to a very great degree. For some time past the efficacy of such a vehicle for the more arduous tasks of plowing, harrowing, and similar operations has been demonstrated, but now it is being devoted to the more versatile requirements of a farm, being employed to drive the auxiliary machinery such as churns, milk separators, pumps, threshing and chaff-cutting machines, and so forth, which have hitherto derived their power from some other source of energy, such as stationary or portable gas, oil, and steam engines. This development is of far-reaching importance to agriculturists, since the gasoline motor possesses innumerable advantages over any other system of generating energy, the most important of which is ever-readiness for work, dispensing with any preliminary preparations, such as steam raising, etc. Moreover, economy in cost and maintenance, both from labor and fuel points of view, flexibility in running, and last, but not least, the primary consideration that when standing idle it does not become an item of expenditure, characterize this engine. It has been proved upon English farms that the acquisition of a motor of this type dispenses with every other source of energy that may be installed, for it will successfully accomplish each and every of the various purposes for which power is required. When climatic conditions prevent its being utilized for land work it can be equally employed for supplying the motive power for the stationary machinery and implements.

This agricultural development has been largely carried out by means of the Ivel agricultural motor. This is a highly efficient and reliable machine, simple in construction, easy to control, and fitted with an engine of sufficient power for all requirements. When installed upon a farm it does not require the acquisition of other special implements, which is invariably the case when mechanical supplants animal power in such cases. Any existing agricultural machinery can be employed with it, the only alteration requisite being the alteration of the poles to which the animals are harnessed and the substitution of a small spring coupling. The 20-horse-power engine has twin cylinders, and the vehicle is provided with one speed forward and reverse. For driving stationary machines a pulley is fitted driven direct off the engine. By the operation of the clutch the driving mechanism of the car is thrown out of gear, and the belt pulley brought into service.

For the plowing test a three-furrow plow was attached to the motor and was kept working for two days. The area of ground treated aggregated 11 acres, 1 rood, 13 poles, which occupied 17 hours, 28 minutes. The soil was loam, rather wet. The total quantity of fuel consumed during the work was $25\frac{1}{2}$ imperial gallons, fuel, lubricating oil, and the men's time in operating the machine.

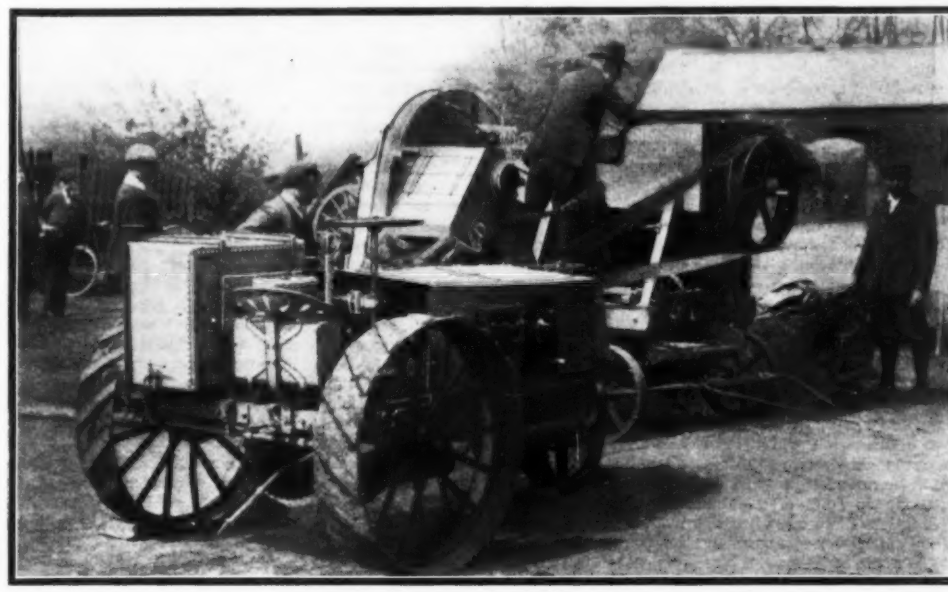
For reaping and binding the motor and its attachment were used in a 32-acre field of wheat. During 10 hours' work, 19 acres were finished, at a consumption of $18\frac{1}{2}$ imperial gallons of gasoline. The cost per acre amounted to 43 cents inclusive.

The results achieved in mowing were more impressive. The field contained a heavy crop of grass, of which 6 acres were cut in 3 hours, 40 minutes, with a fuel consumption of $5\frac{1}{2}$ gallons, together with one pint of lubricating oil. Immediately upon the conclusion of this task the motor was taken to another field containing 3 acres of similar grass, and the whole was cut in the short space of 1 hour 33 minutes. The fuel consumed was 3 gallons; the cost per acre, 43 cents.

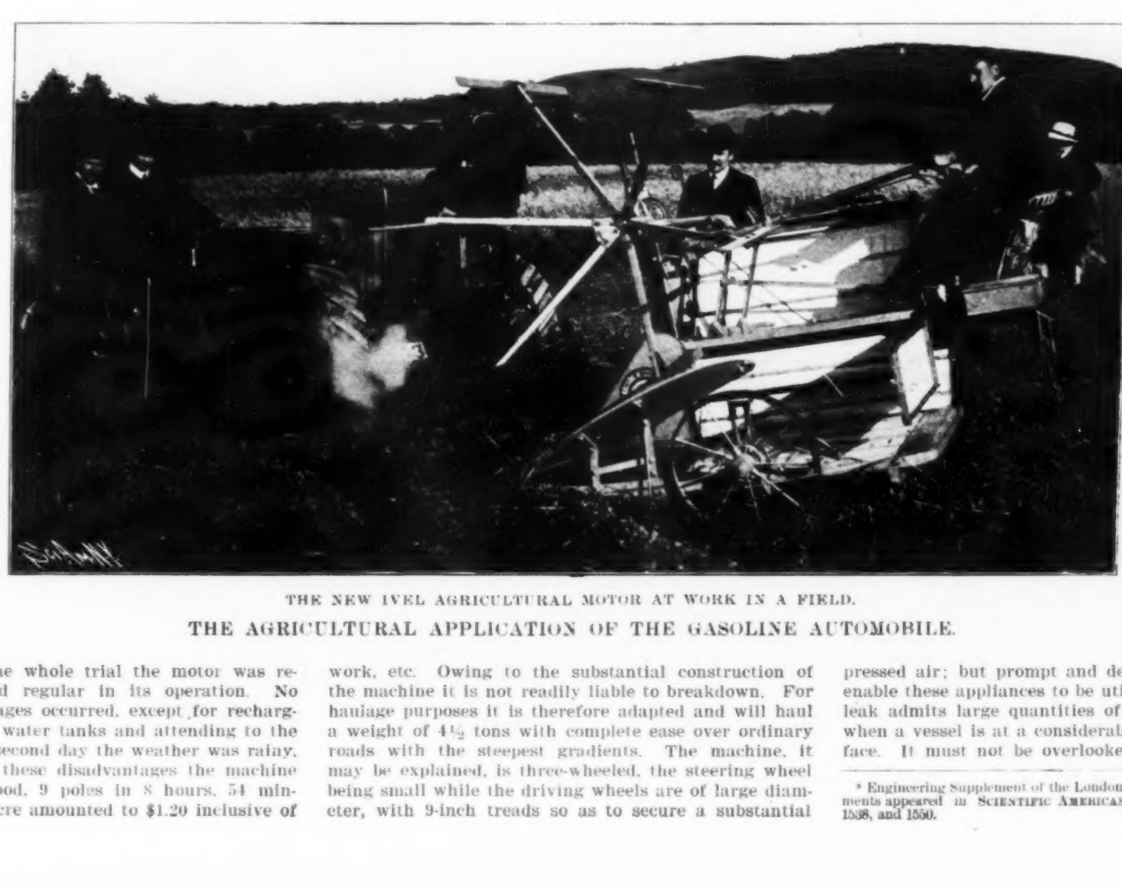
That the appliance is admirably suited to the operations of chaff-cutting and threshing was conclusively demonstrated. The five-knife chaff cutter driven by the motor cut 1 ton $1\frac{1}{2}$ hundredweight of chaff to a gage of $\frac{3}{8}$ inch in 47 minutes; 3 quarts, 1 pint of gasoline was used. The cost of the work was, however, slightly higher than the ordinary agricultural operations, owing to the increased number of laborers required, but it worked out at 60 cents, inclusive of everything. The cost of threshing is somewhat higher in comparison. For this test the motor was attached to a large machine with an elevator 5 feet, double blast, and threshed some very long oats. The fuel consumption averaged $1\frac{1}{2}$ gallons per hour, which, together with the cost of the lubricating oil, represented 50 cents. The labor item, however, was greater, due to more attention being required for the threshing machine.

From the result of these trials it will be at once recognized that the motor is an economical source of power and the initial outlay entailed in the acquisition of the machine—$1,500—is soon recouped by the economies effected in labor, the quicker completion of the work, etc. Owing to the substantial construction of the machine it is not readily liable to breakdown. For haulage purposes it is therefore adapted and will haul a weight of $4\frac{1}{2}$ tons with complete ease over ordinary roads with the steepest gradients. The machine, it may be explained, is three-wheeled, the steering wheel being small while the driving wheels are of large diameter, with 9-inch treads so as to secure a substantial adhesion upon the roads. Loaded with fuel and water it weighs 30 hundredweight, of which aggregate some $22\frac{1}{2}$ hundredweight are upon the driving wheels.

lons. Throughout the whole trial the motor was remarkably steady and regular in its operation. No breakdowns or stoppages occurred, except for recharging the gasoline and water tanks and attending to the lubricators. On the second day the weather was rainy, but notwithstanding these disadvantages the machine plowed 6 acres, 1 rood, 9 poles in 8 hours, 54 minutes. The cost per acre amounted to $1.20 inclusive of



THE IVEL MOTOR USED AS A THRESHER.



THE NEW IVEL AGRICULTURAL MOTOR AT WORK IN A FIELD.

THE AGRICULTURAL APPLICATION OF THE GASOLINE AUTOMOBILE.

SUBMARINES.—V.*

By SIR WILLIAM H. WHITE, K.C.B.

CAPT. BACON considers that "broadly speaking there are two classes of accidents that can happen to a submarine boat—first, the admission of water into the interior; secondly, an explosion." He explains that water may enter through an open hatchway or in consequence of a leak, and he shows that the four serious accidents to modern submarines—"A1" and "A8" of the Royal Navy, the French "Farfadet," and the Russian "Delfin"—have been due to water entering through a hatchway. He is of opinion that "all these cases are of a nature that should not occur again; there is nothing inherent in submarine boats to render any of them liable to recur." This generalization is too wide; the "human element" must always count for much; and, even with crews thoroughly trained and disciplined, mistakes will occasionally be made. Moreover, the necessarily small reserve of buoyancy retained in the diving condition makes a trifling mistake, or a small entry of water, a possible cause of serious danger. This point has already been illustrated in previous articles; but its importance justifies further illustration. In "A8," when "trimmed" and ready for diving, the reserve of buoyancy is only 800 pounds, while the displacement exceeds 200 tons. The reserve of buoyancy is, therefore, less than one-fifth of 1 per cent of the displacement; it corresponds to the weight of only $12\frac{1}{2}$ cubic feet of sea water; 80 gallons of water entering would destroy the reserve of buoyancy and cause the vessel to founder unless it were promptly expelled. Provision is made, of course, for expelling water in such cases by electric and hand pumps, and by compressed air; but prompt and decided action will alone enable these appliances to be utilized; and a very small leak admits large quantities of water in a short time when a vessel is at a considerable depth below the surface. It must not be overlooked that there is a prac-

* Engineering Supplement of the London Times. The previous installments appeared in SCIENTIFIC AMERICAN SUPPLEMENT Nos. 1536, 1537, 1538, and 1550.

tical certainty of a submarine reaching the bottom if from any cause the reserve of buoyancy is temporarily overpowered. In theory, as Capt. Bacon states, "the rate of blowing water from tanks is purposely made so great that a sinking boat should be caught and made buoyant long before a dangerous depth is approached." In practice, the force of gravity is unsleeping and inexorable; immediately the reserve of buoyancy is lost the submarine virtually becomes a falling body, which in a few seconds reaches bottom, even in considerable depths. The inquiry into the loss of "A8" afforded evidence that some of our submarines had reached bottom apparently in moderate depths of water; and there are other cases on record for foreign vessels which have reached bottom at great depths. As depths increase, the difficulty of expelling water grows, and the rate of expulsion becomes slower. Much, of course, depends on the rate of inflow and on the total quantity of water which enters. In some instances it has been practically impossible for crews to use the pumping appliances, although the attempt was made. In the case of "A8," steps in this direction are said to have been taken by the crew, but they are supposed to have been rendered incapable at an early period by gases evolved from the storage batteries; no water was expelled, although that which entered occupied only about one-third of the total air-space in the vessel exclusive of the tanks.

Another important factor is the rapid growth of external pressure as depths increase, and the consequent possibility of deformation or partial collapse of the structure. In "A8," for instance, the volume of displacement when submerged exceeds 7,000 cubic feet, and a deformation which lessens that volume by only 12½ cubic feet destroys the reserve of buoyancy. Capt. Bacon, in connection with his discussion of salvage operations on foundered submarines, gave a chart of the English Channel with the limited areas marked thereon "in which (submarine) boats can sink to the bottom without having their hulls destroyed by the pressure of the water." These areas only fringe the coast-line, and are of small extent. It would appear—although no definite statement is made—that from 27 to 30 fathoms of water is treated as the limit of depth within which the structures of our submarines are capable of resisting external pressure without deformation. But whether this is the assumed safe limit of depth or not, it is noteworthy (as Capt. Bacon remarks) that "our boats navigate the whole waters of the Channel; their radius of action is considerable, and they act absolutely without regard to the depth of water under them." His deduction from the chart is that it constitutes a conclusive argument against providing special plant for the salvage of submarines. While concurring in that opinion attention must be drawn to another deduction of no less importance—viz., that the moderate reserve of buoyancy possessed by submarines in their "surface" condition, and their trifling reserve in the diving condition, necessarily involve exceptional risks of foundering as compared with ordinary vessels in which the reserve of buoyancy is much larger, while the safety of ordinary ships can be increased by minute subdivision into watertight compartments. The latter provision for safety is admittedly inapplicable to submarines, so far as transverse bulkheads are concerned, although the construction of ballast tanks really limits to a considerable extent the internal space to which water can find access. By special precautions and the employment of trained crews these risks may be met to some extent; but they are inherent in submarines and cannot be ignored.

The accident to "A1" arose from her collision (when submerged) with an ordinary ship, whose bottom struck the conning tower near the top. In service, no doubt, such an accident would not be probable, as submarines would endeavor to keep at a safe distance and to use their locomotive torpedoes. "The conning tower was struck. . . . the hatch slightly sprung open; the boat then traveled the whole length under the ship's bottom, during which time sufficient water had leaked in to prevent the boat subsequently rising." The structure of "A1" was otherwise undamaged. This case illustrates the risks inevitable with a very small reserve of buoyancy, and the uncertainty of being able to use appliances for expelling water. It also affords an example of the good uses to which accidents may be put in order to lessen similar risks in future. Watertight hatches are now fitted at the bases of conning towers as well as at the tops in order to guard against moderate leakage if the conning tower is damaged; if "A1" had been so fitted she might not have foundered.

The recent sad accident to the "Farfadet" at Bizerta, according to the best French accounts, was probably due to an imperfect closing of the hatchway in the conning tower, just when the vessel was about to dive. It is supposed that the commanding officer detected the fault, and ordered the cover to be reopened in order that it might be properly secured; but at this instant the vessel dived, an inrush of water took place through an opening about 20 inches in diameter, and in a few seconds the reserve buoyancy was overpowered. The vessel sank to the bottom in comparatively shallow water (about 40 feet), her bow plunging into the mud, and her stern floating at a considerable height above the bow. The air in the interior was compressed into the after-part of the vessel; six men took refuge there and remained alive for a considerable time, responding to signals from outside for 32 hours. Salvage operations were attempted, and at one stage the stern was raised above water and communication established with the imprisoned seamen. Unfortunately, the lifting gear was too weak, it broke and the vessel again became submerged, all the men perishing. Here, again, the primary facts are the small reserve of buoyancy, the mistake made in closing the hatch imperfectly and the impossibility of using appliances for expelling water.

The loss of the Russian submarine "Delfin" was due entirely to want of care in management. The vessel was 77 feet long and about 200 tons displacement. Her regular crew was 12 officers and men, but at the time of the accident 37 men are said to have been on board, nearly all being untrained. The vessel was lying in the Neva, and the less density of the water there (as explained in previous articles) involved a serious increase in draft and loss of freeboard as compared with sea water. The additional and untrained men made matters worse by increasing the load, crowding the space, and keeping the hatch open in their endeavors to escape. Preparations for diving and the admission of water ballast had begun, and the hatchway was thus brought close to the water before it was closed. The swell from a tug passing near swept over the vessel, water entered through the open hatch, and the vessel sank bow foremost, 23 lives being lost. In this case also it is reported that the air was compressed in the higher after-part, and that the electric lights burned for some hours, as the storage batteries remained above the level of water in the interior. The French writer who gives these details wisely adds: "It does not suffice merely to have a submarine vessel in order to possess a weapon of war ready for action; in her management and preparation for service the training of her crew is a factor of the first importance. . . . It cannot be too often stated that time, patience, and careful selection of the crew as well as frequent exercise are essential."

The principal circumstances attending the foundering of "A8" were stated in a preceding article, and it will be understood that they differed from those just described. She was not in her diving condition, but was proceeding at a higher speed and with a much larger reserve of buoyancy when she dived. This case will be further examined hereafter.

Explosion is the second cause of accident mentioned by Capt. Bacon and it requires but few remarks. Three causes of explosion are specified by Capt. Bacon—(1) Those due to mixtures of petrol vapor and air; (2) those due to explosive mixtures produced if storage batteries are flooded with water; (3) explosions of compressed air reservoirs. The third is highly improbable; the second is possible, but should be exceptional; it is supposed to have occurred in "A8" after she foundered. The first class of accident has happened only in "A5," where the official regulations were not observed, and the consequences were very serious. It has been explained that internal combustion engines are essential, under present conditions, to the maintenance of good speed and large radius of action at the surface. On the whole, experience has been favorable to the use of petrol. Capt. Bacon justly claims credit for the fact that "English boats have covered over 30,000 miles using such engines, and that with the exception of one small flash in an early boat no explosion except that in 'A5' has occurred." He lays stress also on the fact that leakage of petrol can always be detected by smell; and he is of opinion that "in a properly designed system leaks should be practically non-existent." This is a "counsel of perfection" not likely to be fulfilled always in actual working. Experiments are being made with heavy oils as substitutes for petrol, and good results are said to have been obtained in some cases. There will be universal agreement that any change which will lessen the risks of explosive mixtures being formed in the interior of submarines is most desirable. At the surface and under way with open hatchways the change of air in a submarine must be so rapid and complete that an explosive mixture can hardly be formed. Under many circumstances, however, such a result may follow upon a leakage of petrol, and it is important to avoid that risk if the essential conditions of surface propulsion can be met while the danger of explosion is minimized.

Previously to the accident to "A8" the writer had indicated his opinion that there is a third possible cause of accident to submarines, not mentioned by Capt. Bacon in his paper—namely, the risk of sudden diving when proceeding at the surface under certain conditions of speed and draft. The evidence given at the inquiry confirms that opinion, and the subject will be dealt with in the next article.

IRON AND STEEL HULL STEAM VESSELS OF THE UNITED STATES.*

By J. H. Morrison, Author of "History of American Steam Navigation."

I. EXPERIMENTAL PERIOD.

The record of the early manufacture of plate iron in this country is very incomplete, to take the most favorable view of it. The producer had no desire to make public any improvement he had made in the manufacture of iron for fear a competitor would appropriate his improvements, to his disadvantage. Besides, there were no publications in this country at the time that catered especially to the iron-manufacturing industry. Such data as can be found on the subject show that prior to about 1800 plate iron was made, or finished, under the tilting hammer; and it is doubtful if there was anything but light sheet iron made between iron rollers, and it must all have been of a very rough surface finish. Such wrought-iron plate as was used for building steam boilers was of English manufacture, as it is found by the advertisements in the daily papers of that period of the arrivals at different times of "— tons English plate iron," "— tons Swedish bar iron," or "— tons Russia sheet iron," that was offered for sale by some commission merchant in the large cities. We also find that Oliver Evans began the construction of the high-pressure cylindrical boiler at Philadelphia, Pa., about 1802, that was built in all probability of iron, as sheet copper would have been very expensive to use in its construction. There were several manufacturers located along the Atlantic coast at this time, and at Pittsburg, Pa., that operated their machinery by steam power. These steam engines were largely of Oliver Evans's manufacture. There were three or four marine boilers built of plate iron by Robert McQueen, of New York, in 1811 and 1813, for steamboats on the Hudson River and the Potomac River, but whether of domestic or foreign material is not positively known. It would not be surprising to find that the iron for these boilers had been especially rolled for the contractors in this country. A copper boiler for a steamboat at this time was a costly piece of work, and iron was sought on account of the less first cost. The iron-rolling mills were also becoming better fitted to produce at this time rolled iron heavier than common sheet iron. The making of rolled boiler plate would seem to have begun as a regular merchantable article in this country about 1815 or 1820, but whether on the Atlantic coast or at Pittsburg, Pa., where the high-pressure marine engine and the plain cylindrical marine boiler first took form about 1817, seems to be a doubt. In 1823 there were but four steamboats in New York waters having iron boilers, the boilers of the other steam vessels being of copper. It is claimed that the Brandywine rolling mill of Charles Lukens at Coatesville, Pa., made the first wrought-iron boiler plate in this country between 1816 and 1825. Imported wrought-iron boiler plate was used for the construction of boilers many years before its manufacture in this country.

About the earliest writing on the making of sheet iron in this country is that by Prof. Thomas Cooper, of Dickinson College of Pennsylvania, in 1813, where he says: "In consequence of information requested of me, I have found it necessary to make some inquiries as to the manufacture of sheet iron. The fault of this article when made in this country is stated to be that the plates or sheets are rough and uneven, in consequence of the scales they acquire in the process of heating for the purpose of being rolled. The appearance of the plates is mended by being annealed or slightly blued, but this is no cure for the evil. My notions on the subject are these:

"Every metal, particularly iron, when exposed to atmospheric air in a red heat, will attract and combine with the oxygen of the atmosphere, and become oxidized. The oxidized iron will either scale off, or remain upon the plate in the form of scales, and make it rough. The cause of the scales and of the roughness of the surface, therefore, is oxidized iron. The cause of the iron becoming oxidized is that a current of air not deprived of its oxygen by the coals comes in contact with the hot iron, and deposits its unconsumed oxygen in the metal.

"When a plate of iron is laid upon charcoal for the purpose of being heated previous to its being rolled, the interstices of the charcoal admit more air than the charcoal can consume, or de-oxygenate; that air combines with the underside of the plate, which thereby becomes rough and scaly; the upper side of the plate becomes less so, because the air that passes over it is in part deprived of its oxygen. If there be three plates, the bottom of the undermost will be most oxidized, and then the top of the uppermost; the middle plate will be free from scales. It is heated in the same manner as if it were in a muffle, which is the method of heating the iron intended to be rolled, in some parts of England, and effectually prevents the imperfection complained of.

"If instead of charcoal a bituminous stone coal is used, the iron plate comes away from the fire much purer and cleaner. The coals are apt to coke together, and admit no more air through them than they can decompose; besides which, the smoke of the coal greatly tends to decompose the current of air which passes immediately under the lowest plate. Coal, therefore, is the best fuel for the purpose, that is, the coal that smokes and flames while it burns.

"But, *if the rollers be well greased* while the iron is passing through them, which they ought to be, the scales separate, the surface becomes smooth, and a fine bluish color can be afterward given by proper annealing, if it be necessary to please the eyesight."

The period from 1835 to 1840, when it may be said iron shipbuilding was introduced in the United States, was one of many changes in marine engineering and shipbuilding in this country, the result of many experiments and trials. Those that have stood the test of time have been: the adoption of the iron boiler in place of those made of sheet copper; the introduction of the independent engine to operate a fan blower, for increasing the draft of the furnaces of the boiler; and the adoption of the screw propeller. Another period, but more recent, was from 1870 to 1875 in the general laying aside of wooden-hull steam vessels on the Atlantic coast, except those for special service, and the larger development of the iron shipbuilding industry, with the introduction at the same time of the compound engine for screw steamers.

The use of iron in the construction of the hulls of steam vessels for the merchant service was not given a great deal of attention in this country until about 1850, for our supply of timber for shipbuilding seemed at the time to be inexhaustible. It is true there were several passenger, freight, and canal boats built of iron prior to that date, but they were small in number and in tonnage to the wooden hulls built during the same period, and with a few exceptions were for inland ser-

* Specially prepared for the Scientific American Supplement.

vice. Among those that were first in operation in this country, were those that were constructed in England for the Savannah River, Georgia. There were also built several steamers for the United States revenue marine service and two for the United States navy during this period.

The larger number of iron steam vessels built for the Atlantic coast up to about 1844 were constructed at the large marine engine works at New York city, but after that year iron shipbuilding yards were established at Wilmington, Del., Philadelphia, Pa., and Camden, N. J., on the Delaware River, since which time but few iron hulls have been built at New York city and the immediate vicinity. There were a number built at a later period for the domestic and also foreign service at Boston, Mass., but few have been built there of late years.

The pioneer of the iron-hull steam vessels in the United States appears to have been one built at York, Pa., in 1825 on the Susquehanna River, and named "Codorus." It was a very small affair, entirely of iron, and was undoubtedly an experiment. The dimensions of the vessel were 60 x 9 x 3 feet deep, with a draft of 12 inches. The ribs were "bent to a greater strength than flat iron," and placed 12 inches apart, probably shaped similar to an angle iron. There is no record left whether this vessel was fitted with side wheels or a stern wheel. They used wood as a fuel in the boiler. The boat remained on the Susquehanna River about two years without any permanent employment, was then taken to Baltimore, Md., and the last record left of the vessel appears that in January, 1829, she was sent to North Carolina to run between Newberne and Beaufort. A Baltimore paper in April, 1830, published under the heading of "The First Iron Steamboat": "We have two or three times during the past year endeavored to set history right in regard to the place at which the first iron steamboat was built in America. The steamboat 'Codorus' was the first iron steamboat built in the United States, as has been repeatedly stated in this and other papers. . . . It was built at York, the hull altogether of iron. . . . The 'Codorus' was afterward brought to this city, where after remaining some time was taken farther south to ply on some small river." The iron was of domestic manufacture.

There does not appear to have been anything further done with iron hulls in the United States until 1835, when a double or twin hull boat was constructed by L. Parmalee, of Poughkeepsie, N. Y., of 5/32-inch plate iron "riveted together in a manner similar to the iron in steam boilers." Each hull was 63 feet by 29 feet 9 inches by 1 foot 8 inches deep, connected together by beams, and these secured to an ash strip riveted to the upper side of each hull, leaving a space of six feet between the inside of the hulls. On these beams the deck was laid, which supported the machinery, the latter being a small horizontal engine and a locomotive boiler, driving a paddle wheel between the hulls. Draft of water, 9 inches. On the trial in October, 1835, on the Erie Canal, where it was designed to place the vessel in use, the engine was found to be too small to obtain a speed over seven miles an hour. As there is no record found of any further trials with the vessel, it may probably be accounted for by the fact of the canal commissioners not approving of the use of steam vessels in the canal for fear of the washing of the banks, through the operation of the wheels and the intended velocity of the vessel. The limit of speed at this day, as fixed by the commissioners, was four miles per hour. This boat was built but a year after Henry Burden, of Troy, N. Y., had constructed the double-hull steamboat "Helen" of wood, for use on the Hudson River.

There was also built in 1836, in the western part of the State of New York, three or four iron-hull canal boats, or barges, as an opposition line of packet boats on the Erie Canal between Rochester and Buffalo, N. Y. In the next year several iron canal boats were built for transportation companies, for freighting on the Pennsylvania State canals, across the Alleghany Mountains to Pittsburg, connecting the Delaware and the Ohio rivers. Some of these vessels were made in several distinct sections, so that when they arrived at a junction of the railroad and canal, they could be readily hoisted with their merchandise to a freight car, transported across the mountains, and again placed in the canal.

The first iron-hull steam vessel built in this country, that was more than an experiment, was the "United States," constructed at the West Point Foundry in New York, from designs of Charles W. Copeland, their superintending engineer, for service on Lake Pontchartrain and canal, in connection with the railroad to New Orleans, La. This is the same vessel that has been called the "Siamese;" that was the shop name. All the records show her name to have been "United States." The vessel was constructed in the summer and fall of 1838 at the foot of Beach Street, and after the parts had been fitted together, they were taken apart and shipped to New Orleans in sections, and mechanics sent to the latter city by the contractors, who re-erected the vessel, and fitted the machinery on board complete for service. The vessel was built with two hulls, each 110 feet long, 7 feet wide, and 3 feet 6 inches deep, placed so there was a space of 11 feet between the inside of the hulls, or 26 feet extreme breadth of the deck. There were two watertight bulkheads in the ends of each hull. The water wheel between the two hulls was of 13 feet diameter and 8 feet wide, with 14-inch buckets. There was a pair of high-pressure engines, 9½-inch cylinder by 42 inches stroke of piston each, driving the paddle wheel placed in the space between the two hulls; steam being furnished by two return-flue boilers, each 20 feet long and 38 inches diameter, with two 14-inch flues. The draft of water when loaded with passengers and baggage was 22 inches, and her average speed was 10 miles per hour. The total cost of this vessel was $17,500. The T iron used for the frames of the vessel was 3¾ x 1¼ x ½ inches, and the angle iron for reverse bars, etc., 2¾ x 2¾ x ⅜ inches. Plate iron for the bottoms of the hulls was No. 5, for bends No. 6, for top No. 8. The T iron used in the construction of this vessel was rolled expressly for the purpose by the Ulster Iron Company, of New York. A special furnace was erected for heating the plates the whole length, 10 feet, similar to the furnaces used for the same purpose at this day. This vessel after a service of three or four years on Lake Pontchartrain is reported to have been sold to a party at Lavaca, Texas. The last record of her appears in her inspection in 1860 at Savannah, Ga., as "United States," iron, 1841, 222 tons.

The Ulster Iron Company, of New York, made ax iron in 1833 or 1834; rolled boiler plate iron in 1836; drew wire rods for screws in 1836. Also made *the first* iron steering rods for steamboats, that were placed on the "Novelty," which ran on the Hudson River.

In December, 1839, the second iron-hull steamboat—calling the "United States" the first—was named "Valley Forge," and was built at Pittsburg, Pa., by the Washington Works of Robinson & Minis, steam-engine builders of that city, for service on the Ohio and Mississippi rivers. This was the first iron hull on the western rivers, and the first iron-hull *side-wheel* steamboat of American construction and material. Her dimensions were 165 x 25 feet x 5 feet 6 inches depth of hold, but she was subsequently lengthened to 180 feet. Keel plates and bottom were ¼ inch thick, and upper sides 3/16 inch thick, and plating run with in-and-out strakes. Frames were of angle iron. The hull was divided by one longitudinal bulkhead along the center line, and three athwartship bulkheads. The material for the hull was furnished by one of the rolling mills at Pittsburg, Pa. The engines were of the usual type of the western river steamboats—high-pressure non-condensing—having two cylinders, each 16 inches diameter by 8 feet stroke. Steam was furnished by four flue boilers, each 24 feet long. This vessel ran successfully on the Ohio River and the Mississippi River until 1842, when she was sunk by fouling a snag in the latter river, was raised and repaired, and continued in service until 1845, when the hull was sold and broken up, and the machinery transferred to the steamboat "Robert Morris." The plates of the hull were of charcoal iron, and when the vessel was laid aside, were found to be worn so thin on the bottom plates—by friction with the shoals of the rivers it was thought—that she became unserviceable after those few years. Later experience with charcoal iron in the construction of the hull of a vessel in this country showed still farther that it was not the best grade of plate iron for the wetted skin of a vessel. One of our large iron shipbuilders said at the opening of the steel era in shipbuilding in this century: "Charcoal iron does not answer very well for ships. It wears away very quickly, and pits, runs in grooves, and corrosion advances very rapidly in it." This would explain why the "Valley Forge" was so short-lived.

There have been many conflicting accounts made regarding the plate iron used in the hulls of the early iron steamboats, whether of domestic or foreign manufacture, and it may be of interest to say that the only imported plate iron in the construction of the hulls, taken as a whole, of the early American steamboats were those of the Savannah River steamboats, and the "W. W. Fry," of Mobile, Ala.

Prior to the construction of the "United States" in 1838, there were a few iron-hull steamboats on the Savannah River in Georgia, that had been constructed in England. The first of these was the "John Randolph," built by John Laird at Birkenhead, England. At this time iron shipbuilding was a comparatively new industry even on the other side of the Atlantic Ocean. The hull of this vessel was sent over in sections, and re-erected by John Cant, a shipbuilder of Savannah, Ga., and completed in July, 1834. The vessel was 110 x 22 feet x 7 feet 6 inches. The engine was of the low-pressure type, built by Fawcett & Co., of Liverpool, and rated as 40 horse-power. The Hon. G. B. Lamar, of Georgia, the owner of the vessel, wrote to the builder of the hull in 1836 regarding the service of the vessel since her completion, as follows:

"The iron steamboat which you constructed and sent out for me in pieces to Savannah, Ga., in 1834, was received and put up and riveted complete within three months' time; and though five men accustomed to such work had been sent at the same time to complete her, I found the expense of them unnecessary, as the pieces had been so well arranged and marked by you, that no difficulty could occur with persons at all conversant with the ordinary construction of boats or vessels; besides which, a larger one since sent to the same place by you for the Steamboat Company of Georgia was put up in even less time, and without any difficulty. In mine, which was called the 'John Randolph,' was placed an English engine of 30-inch cylinder by 5-feet stroke with heavy iron boiler, steam and other pipes, with which, and water and wood for twelve hours (six cords) she drew but 2 feet 9 inches water. She made her first trip in August, 1834, towing flats with cargoes on the Savannah River, the current of which is two and one-half miles per hour, and with the weight of 8,000 bushels of salt—about 200 tons—up, or 1,500 bales of cotton—about 220 tons—down, on the two flats, she made with 18 revolutions of crank per minute 5 miles per hour upward, and over 8 miles per hour down the stream.

"She was kept in constant employment from August 1834, till April, 1835, when her hull was examined inside and out, and found to be uninjured. From July she was again constantly employed till April 1836, when she was again examined, and found free from rust and injury, though from July to December the river had been very low, and she had been once aground for a week on a sand bar, and daily while running on and over logs, snags, and other innumerable impediments, as well as the sand bars, during that time working the flats off and over the bars, very frequently during which they were often snagged and otherwise made leaky, while the steamboat itself, though made to take the worst difficulties, when known to the pilots, was not injured, and remained as tight as at first.

"The preparation to prevent the iron rusting was only three coats white lead inside, and three of red lead outside previous to launching; and one coat white lead inside between August, 1834, and April, 1835, and two coats of each at that time inside and out respectively, and one coat white lead inside between July, 1835, and April, 1836.

"In addition to the foregoing conclusive evidence in her favor, I may add that the directors of the Steamboat Company of Georgia, who had been eighteen years engaged in the navigation of that river, and had tried various projects for its improvement, so soon as they observed the condition of the 'Randolph' in April, 1835, when she was first examined, immediately resolved to order the one you sent out for that company in the month of February last.

"I will take the leave to add as my opinion, and from the experience of the 'John Randolph,' that iron boats are decidedly superior to wooden; and for lightness, durability, impregnability to snags, or other injury, must entirely supersede all other vessels in course of time, should the difficulties apprehended in regard to the compass be overcome."

Congress passed an act in February, 1834, authorizing G. B. Lamar, of Savannah, Ga., "to import free of duty an iron steamboat with its machinery and appurtenances, for the purpose of making an experiment of the aptitude of iron steamboats for the navigation of shallow waters." This referred especially to the "John Randolph." The owners of this vessel were prominent at this period, both politically and commercially, in all affairs affecting that section of the country.

The "John Randolph" having proved in the course of a year's service well adapted for the work intended, the Steamboat Company of Georgia placed an order with the builder of the former vessel for one of 120 x 20 feet x 7 feet 6 inches, which was re-erected at Savannah by Edward Nock. Her name was "Chatham." The engine was of the low-pressure type of 46 horsepower, and was fitted with gearing and a large flywheel, from an old boat formerly on the river.

The Iron Steamboat Company, owners of the "John Randolph," had the hull of another vessel constructed and sent out in sections to this country by John Laird in 1838, and having dimensions of 115 x 24 x 8 feet hold. This vessel was named "Lamar." Instead of importing the machinery with the hull, the engine and boiler for the vessel were constructed by Watchman & Bratt, steam-engine builders of Baltimore, Md., who also put the hull together at Savannah. A duplicate of this vessel was built during the next year by the same builders and named "Savannah," for the Iron Steamboat Company. All these vessels, built by John Laird, had water-tight bulkheads at the fore and after ends of the machinery space. All of these Savannah steamboats had gone out of service by 1852.

There was another imported hull sent to this country in 1839. This was the "W. W. Fry." There have been many errors spread regarding this vessel, but the facts appear to be that John Laird also built this hull, and about the same time he had shipped a few iron hulls to South America. This hull was sent over in sections, arrived at New Orleans, La., in June, 1839, and was shipped from there to Louisville, Ky., where it was re-erected, but by whom does not so far appear. The vessel was 168 x 28 feet x 7 feet 5 inches. Where the machinery was constructed is somewhat in doubt. Davis Embree in 1851 wrote that the vessel was built in Pittsburg, which is an error, but in all probability is where the machinery was constructed. There were four or five machine shops at this date at Louisville, Ky., and one of these had re-erected the hull of the vessel. A Pittsburg steam-engine builder had probably built the engines and boilers, as they had the call for western river engines in that section at that period. She was launched October 9, 1840, and left Louisville the latter part of November, 1840, for New Orleans. The vessel was owned by Alexander and C. M. Pope, of Mobile, Ala., and was intended for the New Orleans and Mobile trade. Her original cost was $19,834. She was snagged while on the Alabama River in 1842, and on March 29, 1855, was again snagged and sunk while in Mobile Bay, subsequently raised and put again in service. Loss about $500. The vessel was finally laid aside by being beached on the flats opposite Mobile about 1860.

A vessel that was a radical departure at this period was the "Robert F. Stockton," built by J. & M. Laird, of Birkenhead, England, in 1839, for Com. R. F. Stockton, United States navy. This vessel not only had an iron hull, but was fitted with a screw propeller, the first of that type of propulsion since the experiments made by John Stevens some thirty years before. What has given the vessel so much prominence has been the fact of her being the first iron-hull vessel to cross the Atlantic Ocean. There had been iron-hull side-wheel vessels built for river and coastwise service in Great

Britain, but this was the first test on the stormy North Atlantic Ocean. Doubts had been entertained if an iron hull was as well fitted for the open sea as a wooden structure. But this voyage set all such doubts at rest. The dimensions of the vessel were 70 x 10 x 3 feet draft, not as large as one of our river tugboats; and the motive power was two engines, each having cylinders 16 x 18-inch stroke. She was brought to New York under sail only, and arrived there May 29, 1839. She was taken, soon after her arrival, to the shops of the Camden & Amboy Railroad Company at Bordentown, N. J., and subjected to many experiments and changes, especially in her motive power. One serious defect was found—that with the two propellers in operation on the one shaft she was very erratic in steering properties; but the removal of one wheel improved her very much. Her rudder was also changed, and placed aft of the propeller. The name was changed by an act of Congress in May, 1840, to "New Jersey." The vessel was placed in service towing barges on the Delaware River and canal, and she continued for about thirty years. This was the first screw vessel that was successfully used for purposes that were not experimental.

(To be continued.)

A FOLDING MALAY KITE.

The kite has long ceased to be the plaything of the boy, and experiments on kite construction and flying are now conducted under the patronage of governments and learned societies. The United States Weather Bureau has considered the subject of kites and auxiliary apparatus for the meteorological exploration of the upper air to be important enough to call for the research of specialists, and the results have been embodied in an interesting monograph. Articles upon the subject have been published in many scientific journals and in the proceedings of learned societies. The number of amateur kite fliers grows larger year by year, and some of their achievements in this direction have been notable. Cameras have been sent up and photographs obtained. Meteorological instruments have been elevated to high altitudes, and even telephone wires have been carried by kites and messages have been transmitted by their aid.

Doubtless many of our readers would like to make the modern kite, either for making observations or simply for pleasure. Dr. Claison S. Wardwell has placed at our disposal one of the kites which he has made for his own use. It possesses many ingenious expedients, which might perhaps not occur to the amateur kite maker. It is a tailless "Malay" kite of the Eddy type, constructed so that it folds in small compass and is what is known as the five-foot size.

Fig. 1 shows the completed kite with the principal dimensions noted on it. Fig. 2 shows the metal cap which is secured to the end of the stick and also the bent wire terminal which secures the cover. Fig. 3 shows the construction of the joint in the cross stick and the attachments for the bridle. Fig. 4 shows the two sticks joined together with waxed braided fish line, and Fig. 5 shows the kite folded.

The best material for the sticks is straight grain spruce, as this wood has been found to be less liable to bend under strain or to break at the cross stick. Of course, considerable care should be exercised in cutting out pieces which are free from imperfections. The sticks are 7/16 inch wide and ⅜ inch thick and 5 feet long. The sticks can be rounded at the edges and scraped smooth. Blocks are glued on to each stick as shown in Fig. 4. On no account should the wood of the stick be scored or cut away at the joint, as this would impair the strength of the joint. The blocks may be secured to the sticks with good carpenter's glue. They should be accurately fitted, so that the joint is a firm one. After gluing, the joint is tightly wrapped with waxed thread and varnished with shellac. The ends of the sticks are provided with No. 32 or No. 38 blank cartridge shells to which a piece of large sized wire is soldered. This wire is afterward drilled to receive the split ring which holds on the bent wire terminal. The stick is shaped at the end to receive the shell, which is secured to it with hot shellac. The sticks are tied together at their juncture with waxed braided fish line, which may be readily untied.

The bridle eyelet, made of hard rubber, is supported by annealed brass wire (No. 13) hammered thin at the ends and bent into shape, as shown in Fig. 3. This is attached to middle of cross stick with waxed thread and varnished. The cross stick is bent to the proper bow (1/10 of its length) and secured with No. 22 spring brass wire, loops having been formed at each end to pass over the ends of the sticks, as shown in Fig. 2. Bend No. 13 spring brass wire into the shape shown in Fig. 2 for the terminals and secure them in place with split rings. Now connect the ends of the sticks with No. 1 picture cord, using great care in the measurements, and allowing the perpendicular stick to bow forward slightly. Now remove the brass bow wire from the cross stick. The kite is now ready for the cover, which may be made from tissue or Manila paper, Chinese silk, or best quality of percaline. With the paper cover the paper is fastened on with good mucilage, leaving the cover flat and smooth. The cover opposite the center of the cross stick and the corners should be reinforced with percaline glued on. Take a few stitches at the corners around the wire. Now place on the bow wire and the cover will be found to have an even and sufficient slack. With a silk or percaline cover, place on the bow wire, and having cut off four pieces of No. 1 picture wire, fasten the two short wires to one bent wire terminal, and the two long wires to another terminal. Place the terminals on the ends of the sticks and draw the wires to the proper position and fasten temporarily. Cut out the cover and baste it on the frame evenly, so that it will lie smooth. Allow about ½ inch hem. Unstring the wire and stitch the cover with a sewing machine, leaving openings at all the corners. String the wire to position again through the hem of the cover and attach permanently to the other terminals while in position on the frame, then reinforce all of the corners. Cut ½-inch hole for the bridle eyelet and its holder, opposite the center of the cross stick, and reinforce the opening with a circle of cloth about 3 inches in diameter. Attach the upper string of the bridle, which is 30 inches in length, to the hard rubber eyelet as shown in Fig. 3. The lower string, which is 54 or 56 inches in length, is attached to the split ring or bent wire terminal as shown in Fig. 1, allowing 8 or 10 inches extra to each string for adjustment.

DR. WARDWELL'S FOLDING MALAY KITE.

In placing the cover on the frame, first place the two side terminals on the ends of the cross stick, then place the upper terminal in position. Lastly stretch on the lower terminal by bowing the midrib slightly forward, then fasten all the corners with the split rings. The bridle should be provided at the point where the flying string is attached with a hard rubber eyelet similar to the one shown in Fig. 3. In using a cloth cover, it is not necessary to make as much provision for slack.

The weight of a 5-foot kite with sticks 7/16 × ⅜-inch material constructed in this way is as follows:

Frame	6 ounces
Percaline cover with wire edges....	4¾ "
Chinese silk cover with wire edges.	2½ "
Manila paper cover with wire edges	3½

A 6-foot kite with sticks ½ × ⅜ inch will weigh as follows:

Frame	7½ ounces
Tissue paper cover with cord edges	1¾ "

The manner of flying a kite of this character was shown in the SCIENTIFIC AMERICAN for September 15, 1894. It is possible to send up a number of the kites tandem, as shown in the engraving in that issue.

An American flag is excellent to attach to the kite line in light airs and should be in possession of every kite flier. A flag 5 × 8 feet of tissue paper will weigh 4 ounces. A 6-foot pine spar ⅜ inch in diameter will weigh 1½ ounces. A tissue paper flag 10 × 15 feet weighs 13½ ounces. An 11-foot jointed pine spar ½ inch in diameter and tapered weighs 6 ounces. The flag is maintained in position so that its lower edge is horizontal, the spar being perpendicular to the ground, by means of three cords which secure the top, middle and bottom of the staff. These cords are secured to the main line by hard rubber eyelets, the main line passing around them, a piece of thin leather preventing chafing. The guy line passes through the eyelet. The upper guy rope is, therefore, short. The middle one, which may be dispensed with in light winds, is longer, and the bottom guy rope is longest of all. At the star end of the flag a hem is made by gluing thin muslin to it. The light spar is run through this hem and tied at intervals with cord. The flag can, of course, be pasted to the spar, but arranging it so that the spar can be withdrawn is preferable.

CAVE DRAWINGS.

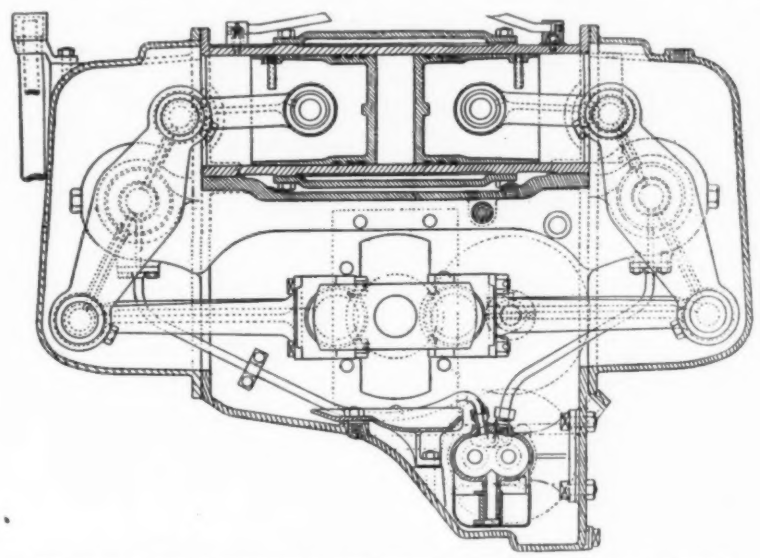
Some time ago, Messrs. Capitan and Breuil discovered some remarkable drawings of animals executed by the men of the reindeer epoch, in several caves of the Dordogne region, in France. In continuing their researches they found other drawings which are of great interest. They found some thirty representations of the mammoth, which is well characterized by its rounded forehead, high skull and the long hairs with which it is covered. In some figures the hair even drags on the ground. This is an indication of the great cold which then existed, and is shown by the thickness of the animal's fur. One very curious drawing seems to represent a great cave-lion, and in front of him are four horses which are admirably executed. Another drawing on the walls of the Combarelles cave shows the front of a feline, while the rest has disappeared under the stalagmite formation. The details of the head are very carefully drawn and are clearer than in the other drawing. A deeply engraved figure in the same cave represents a bear, and they suppose it to be the cave bear as it closely resembles the skeletons we now have. This figure is about two feet high. Very remarkable is the figure of a two-horned rhinoceros which is drawn in red lines at the back of the Font de Gaume cave. It measures 27 inches long. On the top of the head is figured a kind of mane of short hair, and there are indications of hair on other parts of the body. The form of the muzzle and of the head which are much longer than in the existing animals are quite characteristic. The two horns are well shown. The front horn is much longer and thicker than rear one. We recognize in this figure the *Rhinoceros tichorhinus* with its furry covering, like the specimens which are found in the frozen quaternary earths in the extreme north of Siberia. The figures we mention have a great interest as up to the present there were no drawings of the felines or the rhinoceros, and it was even supposed that the *Rhinoceros tichorhinus* no longer existed at the reindeer epoch.

NEW ALUMINIUM COMPOUNDS.

The combinations of chloride of aluminium with oxychloride of carbon form the object of the researches carried on by M. E. Baud, a French scientist, who thus discovers three new compounds. When oxychloride of carbon is liquefied upon anhydrous chloride, this salt dissolves entirely, and when the excess of liquefied gas is evaporated, there remains a colorless liquid solidifying at —2 deg. C., and having the composition Al_2Cl_6, $5COCl_2$. When heated to 30 degrees it abandons $2COCl_2$ and there remains a second liquid compound, Al_2Cl_6, $3COCl_2$, which solidifies at + 9 deg. The latter decomposes at 55 deg. and gives a solid crystalline product in silky needles collected in bunches, having the formula $2Al_2Cl_6$, $COCl_2$. This body decomposes at 150 deg. The three new compounds dissolve in water, giving a solution of aluminium chloride while part of the gas goes off. To analyze them, they must be dissolved in a potash solution. It is found that oxide of carbon does not combine with aluminium by simple addition, but if we send through a red-hot tube a mixture of aluminium chloride vapor and oxide of carbon, the latter is partly reduced, with formation of carbon, aluminium, and chlorine. The chlorine forms with oxide of carbon in excess, an oxychloride which combines with the aluminium chloride, and we obtain a small quantity of the two last-described compounds.

THE WINNING CARS IN THE TOURIST TROPHY RACE.

On September 14 there was held on the Isle of Man a novel 208.5-mile race for touring cars, in which each car was allotted a gallon of gasoline for every 22.43 miles run. The course had a considerable number of hills, but despite this the winning car covered 25.4 miles on a gallon, and ran the entire distance at an average speed of 33.9 miles an hour. Another duplicate car was fourth with a record of 24.6 miles per gallon and a speed of 31.7 miles per hour. The car which won this novel race is a departure from the usual type of four-cylinder automobile. A description of it and of the second and third cars (which made average speeds of 33.6 and 33.4 miles per hour and covered 24.8 and 24.3 miles per gallon respectively) is given herewith.



VERTICAL CROSS-SECTION THROUGH ONE OF THE CYLINDERS AND CRANK CASE OF ARROL-JOHNSTON MOTOR.

THE WINNING ARROL-JOHNSTON TOURIST TROPHY CARS.

It is, to say the least, somewhat of an anomaly that a car fitted with a type of engine generally looked upon as little better than a "freak" should carry off the honors in a race for touring cars, under the strict fuel limitation of which many cars of standard makes went down. This is the Arrol-Johnston, made in Scotland, one of which took first place in the recent English tourists' trophy competition held in the Isle of Man, and another gained fourth place out of something like fifty contestants, eighteen of whom qualified. This is not its only achievement, for in the Scottish reliability trials, held some months ago, it established the unprecedented record of 39 car-miles and 43 ton-miles per gallon of gasoline, in spite of being handicapped by small solid tires and a short wheel base on the type of car then built.

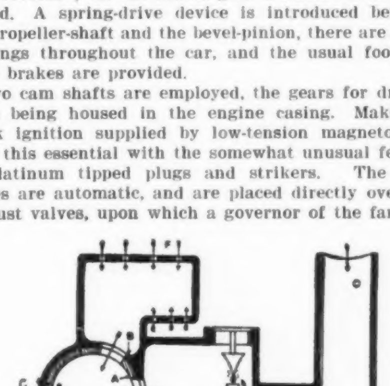
Concerning the cars entered in the last event, they do not, apart from the engine, differ much from current types. The motor is one that, possibly with a single exception, has never before been applied to cars regularly put on the market. Its principle is not new, as it was experimented with almost half a century ago, though not at that time developed beyond the experimental stage, so far as known. This was the Atkinson engine. Numerous experimenters have made use of the same principle with more or less modification since then, but it is not such as would appeal either to the average engineer or layman as possessing any decided advantage over the simpler and universally used single piston type. The only other car upon which it is known to have been used on a commercial scale is the Gobron-Brillé, a French production, in which the engine is vertical. It is a type of which very little is known outside of engineering circles, so that a description of it will be found of interest.

The chief peculiarities of this novel type of car are to be found in the engine, in the control, in the steering gear, and in the wheels. Of these, the engine and its control are by far the most important so far as deviation from ordinary practice goes, for not only has it horizontal cylinders, but it is of a specially "balanced" type and is governed by a "hit-and-miss" device acting on the exhaust-valves. The steering gear itself is of the screw and nut type, and the steering heads for the front wheels are raked considerably instead of being vertical. All four wheels have wire spokes and are shod with 815 x 105 millimeter "Continental" tires.

As our illustrations show, the engine is fixed transversely beneath the low bonnet in front, both it and the four-speed gear-box being secured direct to the pressed-steel main frame. It will similarly be seen that the car is of the live-axle type, with a short propeller-shaft to drive it, and with side radius-rods to tie the axle to the frame. Between the engine and the gear-box, a multiple-disk clutch of the "Hele-Shaw" type is fitted within the flywheel, in such a way as to allow fan-blades to form the spokes of the wheel. The multiple disk clutch is used, and contrary to the usual practice abroad, is not interconnected with the pedal or side brakes or with the engine control. A gear-driven water pump supplemented by a fan formed of the flywheel spokes, which, with the aid of a casing under the engine, forces all the incoming air through the radiator, constitutes the cooling equipment.

Four speeds ahead controlled by a single short lever are provided, the range being 10 to 45 miles an hour. Both cars were geared very high for the race, the winner (No. 53) running at speeds of about 9½, 22, 31½, and 45 miles per hour at normal engine speed (800 revolutions per minute). The gear-mechanism is based on the well-known "Mercedes" pattern, with one sliding member for the first and second speeds, another for the third and fourth speeds, and a third for the "reverse"; on the fourth gear a direct drive is obtained. A spring-drive device is introduced between the propeller-shaft and the bevel-pinion, there are roller bearings throughout the car, and the usual foot and hand brakes are provided.

Two cam shafts are employed, the gears for driving them being housed in the engine casing. Make-and-break ignition supplied by low-tension magneto supplies this essential with the somewhat unusual feature of platinum tipped plugs and strikers. The inlet valves are automatic, and are placed directly over the exhaust valves, upon which a governor of the familiar hit-and-miss type long since discarded by designers of automobile motors acts by preventing it from opening. With a governor of this kind there is no graduation of speed, as once the limit is exceeded the tappet misses the exhaust valve stem and the latter remains closed. The cylinder being full of the burned gases of the last charge, there is but a weak tendency on the part of the inlet valve to open, and no explosion follows. It is an economical method, and though coarse in its action, it can be set by hand to permit the engine not to exceed any speed from 200 to 1,100 revolutions per minute.



CROSS-SECTION OF CARBURETER.

Turning our attention now to the engine, it should first be explained that there are two horizontal cylinders formed by a single casting, and that these are open at both ends, and lie parallel with one another above the two-throw crankshaft. The cylinders, which are close together, are fixed across the car, but the crankshaft is placed longitudinally. Each cylinder has two pistons, the united stroke of which is 6½ inches, and each combustion chamber is formed by the cylindrical space between the two pistons. Ignition occurs alternately in the cylinders, and thus an impulse is given to the crankshaft during each revolution. Each impulse is, however, transmitted to the shaft, through special rock levers, by two connecting-rods traveling in opposite directions, both pistons being forced outward simultaneously. To couple up the pistons with the two connecting-rods, one pivoted rock-lever is mounted in each side of the crank chamber, the lower end of the rock-levers carrying one end of the connecting-rods, and the upper end of the rock-levers being hinged up to a pair of pistons; each pair of pistons that travels outwardly in the same direction, in the two cylinders, are thus yoked up together.

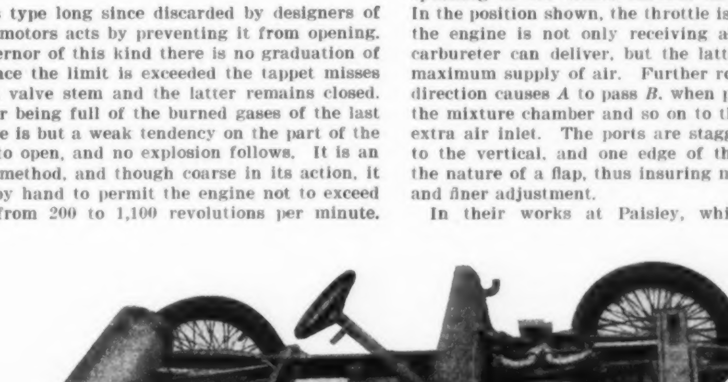
The bore of the cylinders is 4¾ inches, and the engine, which runs at speeds of 200 to 1,100 revolutions per minute, develops 18 brake horse-power at 800 revolutions per minute. It has atmospheric inlet-valves, low-tension igniters that are operated from the same cams as the exhaust valves, and an ingenious inertia governor forms a part of the actuating mechanism. The current is supplied by a magneto. The governor regulates the power of the engine at any desired speed by allowing one or both exhaust valves to remain closed for a time; it, in turn, is controlled by a small wheel and feed-screw on the steering pillar.

Other interesting features of the engine are that the united throw of the crank-pins is less than the combined stroke of the pistons, that no provision is made for varying the "time" of ignition, and that a force pump continually circulates the lubricating oil through the engine when at work. This pump is shown at the bottom of the cross-sectional cut.

The cross-sectional view shown herewith is taken right from the end of the engine as it appears when mounted on the chassis, and thus only shows half of it, the entire mechanism shown being duplicated just behind it. Thus the engine has four pistons with but two cylinders, this arrangement with the cranks set at 180 degrees giving one impulse per revolution to the shaft.

The carbureter is of special design, although embodying the principles recognized as being best fitted to give the result aimed at. The matter of their application will be clear from the sectional view given. It consists of the usual nozzle, the spray from which impinges against a cone, its chief feature lying in the method of supplying air. The main intake is at *C*, with an auxiliary at *F*, the relation between the two being governed by the rotary throttle, *G*. When starting the engine the extra air port in the latter communicating with *F* is opposite the main port, so that a rich mixture is supplied. Rotation of this valve in the direction indicated by the arrow causes the amount taken by the engine to be decreased. At the same time the extra port opens and admits additional air until the maximum is reached, after which any further movement causes the extra air port and the main mixture port opening to be reduced, thus throttling the engine. When both ports in the valve pass the openings in the case there is a complete cut off, corresponding to the closed throttle on other carbureters. In the position shown, the throttle is fully open, so that the engine is not only receiving all the mixture the carbureter can deliver, but the latter is receiving the maximum supply of air. Further rotation in the same direction causes *A* to pass *B*, when pure air passes into the mixture chamber and so on to the engine from the extra air inlet. The ports are staggered with relation to the vertical, and one edge of the extra port is in the nature of a flap, thus insuring more gradual action and finer adjustment.

In their works at Paisley, which are admirably adapted for the manufacture of motor vehicles in large quantities, every facility has been provided for insuring first-class workmanship, and special attention has been paid to the all-important question of suitable materials for each and every part of a modern touring car.



VIEW OF THE CHASSIS OF CAR WHICH WON THE TOURIST TROPHY RACE.

View of the victorious Arrol-Johnston chassis, which completed the circuit of 208.5 miles, at an average speed of 33.9 miles an hour. The chassis, which is of the live axle type, is peculiar for its two-cylinder horizontal engine, which has four pistons.

THE TOURIST TROPHY ROLLS-ROYCE CARS.

The car which succeeded in securing second place in the race is of the usual four-cylinder type, and only differed from a sister vehicle in having slightly smaller cylinders. The bore is 95 millimeters as against 100 millimeters, but the stroke is 127 millimeters in both cases. As already announced, the special feature of the transmission mechanism is that the "direct-through-drive" is arranged for the third speed instead of the fourth speed.

THE TOURIST TROPHY VINOT CAR.

Except in respect of "gearing" this vehicle may be said to be an absolutely standard touring vehicle, without the slightest trace of "freakishness." It was geared high, no doubt, for at the normal engine speed of 900 revolutions per minute it could travel at speeds of 13, 25¼, and 42½ miles per hour, but, on the other hand, it is worthy of special notice that only three forward speeds were available. Of the chain-driven type (with two side chains), with a 14-horse-power vertical engine having four cylinders, and provided with an ordinary cone clutch, the vehicle is in its general design of quite a northodox pattern. It is, however, one of the 1905 models which attracted our special attention at the last Paris Salon, for it, like the other cars made by the same firm, and exhibited on their stall, has many excellent features and is particularly well finished. One striking characteristic, which we mentioned at the time, is the ingenious manner in which the "Mercedes" type of change-speed gear is operated.

The actual car, which did so well in the race, and came in third, was fitted with only one ignition system, and that a comparatively unknown system. It had low-tension "make-and-break" igniters of the "Caron" type, which might easily be mistaken for high-tension spark-plugs, since they are but little larger. Each igniter, however, contains the necessary magnetic device for operating the moving member automatically, and is merely connected up with the magneto through a "timable" commutator. The bore and stroke of the cylinders are 90 and 130 millimeters respectively.

For the above descriptions and the illustrations, we are indebted to the Automotor Journal and the Motor World.

THE MANUFACTURE OF SEVRES WARE.*

By PROF. ALBERT GRANGER.

ALTHOUGH porcelain is a variety of pottery which was known in quite ancient times, it was not made in Europe until within a comparatively recent period. Without stopping to inquire what nation first produced porcelain, we shall confine ourselves to recalling that it has been common in China since the time of the Han dynasty, 163 B. C. Indeed, if we may believe the chronicles, there was a functionary known as the superintendent of pottery in the reign of the Emperor Hoang-ti (2698-2599 B. C.) In Europe, porcelain made its first appearance very much later. It was imported by sailors in the first half of the fifth century, but it was not until 1709 that porcelain made in imitation of the Chinese article was produced in a European factory, at Meissen, in Saxony.

In France, porcelain of this sort was not manufactured until 1769. It is true that a variety of porcelain had been made in France since 1695, but this ware differed in character from Oriental porcelain. It was the soft porcelain, to the consideration of which we shall return later.

Ordinary, or hard porcelain, with a glaze composed chiefly of felspar, and a paste of quartz, felspar, and kaolin, could not be made in France until after the discovery there of deposits of the materials required in its manufacture. Kaolin was discovered at St. Yrieix in 1765, before which date the establishment of a porcelain factory was impossible, owing to the lack of a suitable clay, though the other minerals were obtainable.

The royal manufactory, first established at Vincennes, but removed to Sèvres in 1756, began making porcelain in 1768. In the following year Macquer, who had initiated the manufacture, read a memoir and presented specimens of porcelain to the Academy of Sciences. The composition of the paste has undergone modifications since then. At first, no minerals containing felspar were added, the kaolin, washed on the spot, being simply mixed with silicious sand and chalk. The only felspar or mica which the paste contained was that which the imperfect washing had left in the kaolin. The paste of modern Sèvres hard porcelain has a composition represented by the following formula, which was adopted by the director, Brongniart, in 1836, and is still in use: Pure kaolin 65, felspar 15, quartz 14.5, and chalk 5.5 per cent.

The paste is made at Sèvres by the processes commonly used in potteries. The ingredients, after being ground, if hard, are stirred up with water and mixed in the desired proportions. The watery mixture is passed through sieves and condensed in a filter press to a consistence suitable for molding. Immediately before molding, it is kneaded.

In a manufacture in which the production of fine specimens dominates every other consideration, machine molding plays a subordinate part. In place of the machine calibrating (*calibrage*) employed in the rapid manufacture of many identical pieces, we find here the hand sketching (*ébauchage*) made necessary by the great variety of design. The workman first makes a sketch, that is, he gives to the lump of paste on the wheel the approximate form of the object which he wishes to produce. After the sketch has become sufficiently hardened by drying, it is "turned," or worked down with a cutting tool to its final shape.

Machine molding was introduced chiefly for the production of round plates and oval dishes. These machines are used in making a plate. The function of the first, the "crusting" machine (*crouteuse*) is to transform the ball of paste which is to form the plate into a circular crust, like a pie-crust. The operation is performed rapidly and automatically by means of a vertical lathe and a knife.*

When the paste has been spread out into a "crust," the knife rises automatically. At this moment an assistant removes the drum and replaces it by another containing a lump of paste, which the knife, at its next descent, will convert into another crust. The drum containing the crust is inverted and fastened to a disk. On the spindle beneath is fixed a convex mold which will shape the concavity of the top of the plate when the inverted crust is pressed upon it by lowering the disk. Then the drum is separated from the crust, the spindle is set rotating and the crust is pressed against the mold with a sponge. This operation finished, the mold, covered with the crust, is removed from the second and put on the third machine, or calibrator (*calibreuse*).

By depressing the pedal, the driving belt is shifted from a loose to the working pulley, and the spindle and drum are set into rotation. By means of the handle at the top of the machine a metal scraper, shaped like the profile of the bottom of the finished plate, is lowered until it touches the crust and gives it the desired form.

A similar molding process is used for oval pieces, but here the problem is more difficult, because it is necessary to give an elliptical motion to the mold, in order to bring every part of the plate successively under the scraper.†

Finally, the mold, bearing the calibrated plate or dish, is taken off the machine, and the plate is then separated from the mold, smoothed and polished.

Firing.—The porcelain first undergoes a preliminary process of firing, which is called "hardening" (*cuire en dégourdi*) and consists in exposing it to a temperature high enough to convert the clay, or hydrated silicate of alumina, into an anhydrous silicate which cannot be re-hydrated by the direct action of water. In this first firing the paste loses its plastic character and is transformed into a solid, though porous, material which can be soaked in water without disintegrating.

This hardened paste, or *dégourdi*, is next glazed. The glazing bath is composed of pegmatite, ground and mixed with water. The porous porcelain, immersed in this bath, absorbs water, and the solid matter which was in suspension in the water is deposited over the entire surface of the object, forming a coating which will fuse to a transparent glaze in firing. The immersion is very brief; a plate, for instance, is immersed only a few seconds. This method of glazing by dipping or immersion, is not applicable in all cases, as large objects do not lend themselves readily to manipulations of this sort. Such objects are consequently glazed by spraying. The glaze, suspended in water, as before, is sprayed over the object with an atomizer. In order to obtain a uniform coating the piece of porcelain is placed on a support which can turn about an axis, so that every part may be exposed in succession to the spray of glaze.

The piece being thus coated with glaze must now be fired again, and at this point the real difficulties begin. In the first place, those parts of the object upon which it rests must be freed from glaze, in order to prevent adhesion of the piece to its support; in the second, it is necessary, with many objects, to employ special devices to prevent deformation in firing. At the moment of vitrification, the paste both contracts and loses its stiffness, or, in other words, a molecular change takes place throughout the mass at a time when its resistance is weakened. It is necessary to preserve the shape of the object, while allowing it to contract. For a cup-shaped vessel a conical support of very wide angle is used, and the vessel is placed on it, bottom upward. The slight slope of the support does not prevent contraction, while its circular form preserves the rotundity of the vessel. Examples of forms more complex and more difficult to fire are presented by statuettes in biscuit ware. Many represent figures in motion, with arms, legs, or other parts of the body thrust forward or backward. Fired without special precautions, such a statuette would come spoiled from the kiln. A system of props must therefore be arranged to support all parts that are liable to deformation. These props are fragments of unfired paste, identical in composition with that of which the statuette is formed, so that in firing the support and the part supported will contract equally, and deformation will thus be avoided. By means of a special composition, called "terrage," continued contact between the porcelain and its supports, after firing, is prevented. The final polishing removes all roughness of surface.

Porcelains which are to be fired cannot be placed in the kiln without protection, as they would be soiled by soot and unburned fuel. They are inclosed in earthen *gazettes*. A gazette is a vessel of refractory clay, usually cylindrical, with a bottom but no cover. The gazettes are piled, one above another, in the kiln, the height of each being increased, if the objects to be fired are tall, by one or more hollow earthen cylinders, called *cerces*. The porcelains rest directly upon *rondeaux*, which are round plates laid on the bottoms of the gazettes. The *encastage*, that is to say, the gazettes and their contents, being ready, the kiln is closed and the firing begins.*

The firing of porcelain comprises two stages: low firing and high firing (*petit feu* and *grand feu*). In the first stage, or low firing, the pieces of porcelain are heated slowly. The progressive elevation of temperature allows them to be raised to a higher degree than they could attain without danger of breaking, if heated rapidly. In firing with wood, which is practised at Sèvres, the furnace is first filled with large logs, which burn slowly, producing much smoke and leaving a bed of live embers. In this part of the operation, the low firing, a red heat may be attained, intermediate between dull red and bright cherry red. By this time the furnace has accumulated a sufficient quantity of live coals. The plates of sheet iron which have covered the upper part during the low firing are now removed, and this part is filled with small wood, supported by two iron bridges, or andirons. The radiation from the coals below raises the small wood to the temperature of distillation, and the gases which are disengaged are so hot that they take fire on coming into contact with the air, which now flows through the furnace from top to bottom. The flames thus produced are carried down to the bottom of the furnace by the descending current of air, and enter the kiln. Here the combustion is completed and the atmosphere becomes very hot, oxidizing if the proportion of air is sufficient to consume all the combustible matter, reducing in the opposite case. The maximum temperature is obtained with a neutral plane, that is to say, when there is just sufficient air for complete combustion, but no excess of oxygen. It is very desirable, not only to know whether the flame is oxidizing or reducing, but to be able to give it either character, at will. The use of the oxidizing flame throughout the firing is likely to impair the beauty of the product, because it converts the iron, which is always present in the clay, into sesquioxide, which gives the porcelain a yellow or smoky tint. A more satisfactory result is obtained by employing a reducing flame in firing until the glaze begins to melt, for as long as the porcelain and the glaze remain porous, a reducing atmosphere is required to preserve the iron in the ferrous state. But when the glaze melts it forms an impervious coating which prevents further oxidation, so that the sesquioxide can not be formed and the paste remains white. From this moment it is safe to admit sufficient air to produce a neutral, or even an oxidizing, flame, and to go on firing with this to the point of vitrification.

The proper moment for arresting the firing is determined by the use of control pieces, or samples, which are of two sorts, empirical and theoretical. The former are pieces of porcelain dipped in glaze, which are removed from the kiln from time to time to note the degree of vitrification of the paste and the smoothness of the glaze, which should be perfect when the firing is stopped. The theoretical, or fusible, try-pieces are pyroscopes, the fusion of which indicates that certain definite temperatures have been reached. Being made of more or less complex mixtures of silicates, that is, of materials of the same nature as the constituents of the porcelain, they are ideal pyroscopes for ceramic purposes.

When the firing is completed the furnace is closed with bricks and the kiln is allowed to cool gradually.

Decoration.—Hitherto we have considered only the manufacture of white porcelain. The decoration of porcelain may be effected by two very distinct methods: by high firing, that is to say, while the paste is acquiring the properties which convert it into porcelain, or by a subsequent low firing, or muffling, the colors being applied to the finished white porcelain. In decoration by high firing use is made either of glazes colored by the addition of metallic oxides soluble in the glaze, or of under-glaze colors, so called because they are laid on the paste before the glaze is applied. The palette for decoration by high firing is necessarily very limited because there are few pigments which preserve their tints unchanged at the temperature of vitrification. We are restricted to the use of oxides of cobalt, nickel, chromium, titanium, uranium, iron, manganese, and copper. The colors thus obtained are blue, brown, green, sea-green, yellow, black, violet, and reddish yellow. Copper and gold enter into the composition of certain shades of red and pink.

In decoration by low firing, the supplementary firing

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XX Siècle.

* The workman adjusts to the lathe head a shallow drum formed of leather stretched over a brass ring. In this drum he deposits the ball of paste and depresses, first the left hand, and then the right hand pedal. The former sets the drum spinning; the latter starts the machinery which drives the knife. The essential part of this is a cam which lowers and raises the knife once in each revolution. As the knife descends it flattens the ball of paste and spreads it out into a circular disk.

† This is accomplished by giving a corresponding motion to the lathe head. For this purpose the part of the apparatus which carries the mold is supported by a slide which has at each end a guide, perpendicular to itself. These guides press against a bronze ring, the center of which is movable in the principal median plane of the apparatus. In the case in which the axes of this ring and the spindle coincide the rotation of the latter causes merely a rotation of the mold, but when the center of the bronze ring is displaced, the motion becomes very different. As the slide is perpendicular to the major axis of the elliptical dish, it follows that, after a quarter of a revolution, the dish has been displaced by the movement of the slide so that it has moved outward from the center, in the direction of its minor axis, through a distance equal to the eccentricity of the bronze ring. In consequence of this motion the rim of the dish remains under the calibrating scraper throughout this (and subsequent) quarter revolutions.

* The kiln is a vertical cylinder surmounted by a dome, from the center of which the flue rises. The combustible gases evolved in the furnace enter the kiln through an intake at the bottom. The kiln is divided, by a horizontal partition, into two chambers. In the lower chamber, where the flames act directly and the temperature is higher than in the upper, the second or true firing takes place. This compartment of the kiln is called the "laboratory;" the upper chamber, in which the preliminary firing, or hardening, is effected, is known as the "globe." The firing temperature for porcelain of the composition given at the beginning of this article, is about 1370 deg. C. The temperature of the globe is lower, nearly coinciding with the melting point of gold. The furnace requires a word of description, because it is very different from the grated furnaces with which the reader is familiar. In trade parlance, it is called "alandier," and it consists of a rectangular chamber of brickwork, open at the top, built at the side of the kiln and communicating with the "laboratory" by a hole in the wall of the latter.

is done in special ovens, called muffles. These are vessels of terra-cotta, in which the pieces are heated, by a furnace beneath them, to a temperature high enough to fuse the glaze and the colors together. The glaze is a lead or lead-alkali glass colored by small quantities of dissolved oxides. The porcelain colors are mixtures of suitable fluxes with larger proportions of oxides than the glazes contain. The quantity of flux is not sufficient to dissolve all the oxide, so that the color remains opaque. Within the limits of temperature attainable in muffle firing, the decorator has at his disposal a greater variety of tones than in high-firing decoration, and consequently this species of painting on porcelain has long enjoyed a great reputation, which it still retains, despite all the attempts which have been made to educate the eye of the public to decoration by high firing, which is more strictly ceramic in character, though more somber in tone.

The hard porcelain of Sèvres, of whose manufacture we have given a summary sketch, is not above criticism from the decorative point of view. It was too rich in alumina, and its glaze was not adapted to perfect fusion with the colors. In 1880 MM. Lauth and Vogt established the manufacture of a more silicious porcelain, with a calcareous glaze, which lends itself more readily to ornamentation, and is still known by the name of "new porcelain." It is almost identical with Oriental porcelain in its style of decoration with brilliantly colored glazes, under-glazes, enamels, etc. It is fired at a rather lower temperature, about 1270 deg. C.

Soft Porcelain.—The renown of Sèvres ware was originally based on soft porcelain, of which it is proper, therefore, to say a few words. Soft porcelain was composed of an alkaline frit and a calcareous earth, or marl. The frit was made by heating a mixture of lime, potash and soda salts, stopping short of complete vitrification. The mass was then ground with sand and mixed with the marl, which conferred plasticity. This soft porcelain paste could not be molded satisfactorily and its firing was difficult. Hellot says that when he came to Vincennes, from two-thirds to three-fourths of each batch were spoiled in firing. On the other hand, of all porcelains soft porcelain has always lent itself best to decoration. Its glaze, a true glass, fuses and blends perfectly with the colors, to which it gives a brilliancy and a gloss not attainable in any variety of hard porcelain.

The manufacture of soft porcelain was abandoned by Brongniart in 1804, but this step was subsequently regretted and attempts were made to revive the manufacture. At the Paris Exposition of 1900 the Sèvres establishment exhibited specimens of soft porcelain of composition somewhat different from that of the original ware. The frit was replaced by Stas glass, the marl by a plastic clay. The result was so successful and so greatly admired that especial interest attaches to this revival.

The very curious fact that the soft porcelain which first established the reputation of Sèvres has now, after vanishing for a century, reappeared to add to the success of the national porcelain-factory, proves once more that the prosperity of a manufacture depends, not upon formulas and receipts, but upon the intelligence and perseverance of the men by whom it is directed.

ENGINEERING NOTES.

The demands for increased horse-power are met by grate surface too large in proportion to the heating surface of the boiler or forced draft, and too little attention is given to careful firing, with heating and grate surfaces in proper proportion to give best economy, and frequently a great deal of money is spent in obtaining high-class engines and condensers, whereas the principal loss is in the boiler and fire room.

Piston valves in locomotives were used as long ago as 1833, and since that time there have been revivals at various periods; but like some vaccinations, they did not seem to take—until within the last few years. Whether they are to become a fixture and force the D slide valve to the museum remains to be seen. Inquiries of leading roads using large numbers of piston valves, fail to bring out an expression as to which type of valve is doing the better work, the slide or the piston valve. They will say that they are both doing good work when properly designed. There are two types of the piston valve—inside and outside admission. Some are solid and some hollow. It is this modification that brings about the difference of opinion as to their respective merits.

In repairing old work, care should be taken to remove all traces of rust previous to laying on the new coat. It is not an altogether uncommon practice to repaint old structures by dealing only with the parts readily accessible, which, being less liable to rust, probably but little need it; leaving those parts which are difficult of access, and where rust is developing, untouched; treating the whole business as a matter of appearance simply. This, it need hardly be said, is indefensible. It is better rather to neglect the surfaces freely exposed and ventilated, and devote the whole care upon those other parts, confined and difficult to get at; taking the trouble necessary to remove ballast timber, or whatever may obstruct the operation, in order that the bad places may be thoroughly scraped, and then painted. Those parts which most need attention may cost, perhaps, to reach—and deal with when exposed—ten times as much per yard of surface as the rest of the superficies, which needs little, and is always accessible; but the cost should not deter the proper carrying out of the work, as it will prove the very worst sort of economy to deal with painting in a perfunctory manner.

SCIENCE NOTES.

In Switzerland grape leaves are applied to medicinal or surgical uses. For cuts and fresh wounds they are esteemed a sovereign remedy. Decoctions of the juice of the leaves are used in poultices. An agreeable tea is also made from the leaves which is said to greatly strengthen the nerves. In its use more sugar is necessary than for tea from the tea plant. The leaves are also excellent food for cows, sheep, and hogs. The "tears" of the vine, used medicinally, are a limpid exudation of the sap at the time the plant begins budding, and are found on the vine where the slightest wound occurs to the plant. The liquid is collected by cutting off the ends of the canes, bending them down and sticking the ends into the neck of a bottle, which will be filled in a few days. The wood and branches are used in the manufacture of baskets, furniture, rustic work, bark for tying material, etc., and when burned furnish potash and salts.

Photographic pictures from the captive balloon or a kite are of a great value, not only for topographic observation, but also for war purposes. They were turned to practical use in the Russo-Japanese war. The Russian Topographic Institute of St. Petersburg had built a number of special apparatus for taking automatic balloon views, to be used at the Asiatic theater of war. These apparatus deviate in construction very materially from the ordinary camera. According to Das Echo, the whole apparatus consists of seven photographic cameras, the axis of one of which is perpendicular, and which consequently takes a picture of the view directly underneath it, while the remaining six are arranged in a circle around it, their axes having an inclination of 30 degrees to the horizontal. All that part of the territory which is not taken in by the perpendicularly turned-down camera will fall into the pictures of the remaining cameras, so that everything round about up to the horizon is included in the photographs. The operation of the seven shutters for instantaneous exposure is effected simultaneously by the electric current. To cause the automatic exposure to take place only when the apparatus is at a sufficient height and in a perfectly horizontal position, a leveling apparatus and a clockwork which closes the contact after a certain period have been ingeniously inserted in the circuit.

The essentials for the growth of most of our cultivated plants are that they shall have favorable light, air, temperature, and moisture conditions for the growth of the leaves, stems, and fruits, and a favorable quantity of air and moisture in the soil, with such soluble compounds of nitrogen, phosphorus, potassium, calcium, magnesium, and iron as are best adapted to the particular crop. The demonstration of these requirements has placed in the hands of the farmer the means of maintaining and increasing the fertility of the soil, and has enabled him in many cases to make soils productive that before were barren. The knowledge that plants need light and air and that the larger portion of their food comes from the air has brought about a modification of cultural conditions by giving plants more room in which to grow, with a consequently greatly increased yield. Based on a scientific knowledge of nutrition, the art of feeding plants has developed within the last fifty years in a most remarkable degree. The well-informed farmer now knows that the varying combinations of essential conditions and elements that occur naturally in different soils and climates are an index to the adaptability of these climates and soils for special crops. He knows also that these conditions can be modified favorably or unfavorably by cultivation and fertilization. He understands the importance of a physical and chemical examination of soils as indicating the presence or absence and the relative proportions of the essential elements of plant food.

We have several bodies of correlated relations which constitute such sciences as astronomy, chemistry, biology, and so on. The phenomena exhibited by large bodies at great distances apart we call astronomy. Such as are exhibited by minute bodies near together we call chemistry, and the phenomena among living as distinguished from what we call dead things, we call biology. Among these and other similar sciences, where we have noted the uniformities in the phenomena and find ourselves able to predict occurrences, we say we have definite knowledge, and especially so when the bodies that exhibit the changes are of such magnitude that we may control them. This is what is meant by experimentation. Until phenomena are studied in their relations to other known and established relations they cannot be said to be a corporate part of science. There are many isolated facts not yet in established relations, awaiting their proper setting. Facts are always scientific data, they are not science itself. That a body left unsupported will fall to the ground has been known for thousands of years, also that the moon revolves about the earth. The correlation that shows that both belong to the same class and are due to the same agency, gravitation, is science. The man who proved the relation was a scientific man, was doing scientific work. In like manner everybody has known in all times of mankind and animals on the earth. The correlations that show their relationship is science, and the one who showed it was a scientific man. The two examples are to show that scientific work consists in establishing the relations among phenomena. This is what marks the profound difference between the work of the nineteenth century and all the preceding ones—the establishment of the relations among phenomena.

ELECTRICAL NOTES.

The Borough Council authorities of Poplar, London, propose to adopt the system of electrolyzing sea or salt water for disinfecting purposes. The fluid can be manufactured so cheaply that it may be applied to the streets and sewers. It is a germicide, a disinfectant, an antiseptic, a deodorant, and a bleaching agent, and it can also be used as a medicine for internal use. Experiments with the fluid have proven entirely successful in demonstrating its efficiency.

In a recent memoir presented to the French Academy of Sciences, Mr. B. Sabat records some experiments made with a view to ascertaining the effect exerted by radium bromide on the electrical resistance of metals. The resistances tested were wires 0.1 millimeter to 1 millimeter in diameter, which had been wound on thin paper tubes within which a glass bulb containing two grammes of radium bromide had been placed. The following conclusions are enunciated by the author: Radium bromide, on being placed in the neighborhood of metal wires (bismuth, iron, steel, copper, platinum, brass, German silver) will augment their electrical resistance. This increase in resistance occurs immediately after the metals have been submitted to the action of the radium. The resistance afterward goes on increasing for some time until a practically constant value is attained. As the radium is withdrawn, the resistance slowly resumes its initial value. The variation in resistance will sometimes assume a value greater than that which radium alone would be able to produce, as the temperature of the metal wires is augmented by the heat evolution of the radium. The author thinks that Becquerel rays, and more especially α rays, being transformed partly into heat energy, the temperature of the metals is raised and their electrical resistance augmented.

A diaphragm has been introduced by the Auto-Metallurgic Company, a French firm, designed to prevent the intermingling of liquids situated on the two sides, allowing of the passage of the electric current, and yielding in consequence of the albumenoid or organic matters which it contains of itself a deposit having all the qualities of a deposit obtained from a solution to which the albumenoid or organic substances have been added. This diaphragm consists of any permeable fabric of animal, vegetable or mineral origin, which has been impregnated with albumenoid or organic substances, such as albumen and gelatine. These substances are rendered insoluble by immersion for a time in formic aldehyde, or by other suitable process. Such diaphragms are economical and may be made of any dimensions. While allowing the electric current to pass, and preventing any mixture of the liquids, they of course prevent impurities from passing from the anode to the cathode, and, either on account of their filtering action, or in consequence of a special action on the current itself by deviating the electric waves, they are said to communicate to the deposit of the metal treated all the physical and mechanical qualities of the same metal when worked and finished. The inconvenience resulting from the fact that the percentage of the albumenoid or organic matters is not constant, is said to be avoided by the use of these diaphragms.

A description of a novel electric safety lamp due to Dr. Tommasi is described in a recent issue of La Energia Eléctrica. The inventor has set himself the task of obtaining perfect safety in the use of incandescent lamps, thus adapting electric lighting to mines where firedamp is produced, as well as to powder factories and the like. Electric incandescent lamps are known to be rather imperfect from the point of view of safety. If, because of some accident, the bulb is broken, the filament will be burned by its contact with the air. So far from being instantaneous, this combustion will, however, be attended not only by the projection of incandescent particles, but as well by sparks which, though very small, may be sufficient to ignite a mixture of air and gas, or of air and powder, as found in suspension at certain places, thus giving rise to an explosion. In order to avoid this risk, the contact of the surrounding air with the incandescent filament must be avoided, and this problem has been solved in the new lamp. The lamp proper, which may be of any type, is mounted within a glass cylinder closed at one end by the support of the apparatus and at the other by a cover provided with a small key, this double closure being perfectly tight. The conductors are fixed to the screws carried by the support. Within the support, there is a small India-rubber bellows intended to lift a metallic contact arranged within its lower part, thus interrupting the current, as long as the bellows is not filled with air. In order to start the lamp, the bellows should be filled with air by means of a special caoutchouc tube terminating in a pear-shaped bulb, when the contact will be established and the circuit completed. In order to extinguish the lamp, it is sufficient to open a key. The compressed air which will then escape from the bellows will separate the metallic contact referred to above, thus interrupting the circuit. If for some reason or other the glass cylinder be broken, the pressure will drop and the volume of the bellows decrease, thus producing the same effect as by opening the key. The contacts being accordingly discontinued, the current will be interrupted and the lamp extinguished. If the bulb of the lamp should be broken, the inclosed air would expand by a volume equivalent to that of the bulb, this being sufficient to contract the bellows, to interrupt the circuit, and to extinguish the lamp. The apparatus can be completed by the addition of one or two very light accumulators of the Tommasi system, so as to become transportable.

TRADE NOTES AND RECIPES.

Direct Production of Solid Percarbonate of Soda.—This salt may be obtained, it is said, in a very simple way by the Bauer process, in quantity and directly in the solid state, by causing the reaction on each other of liquid carbonic acid and hydrated sodium peroxide, or the crystallized peroxide. The ingredients are mingled, taking care that the carbonic acid is somewhat in excess. The excess is necessary to insure the exothermic reaction. A brisk reaction ensues, and, without loss of oxygen, a pasty mass is produced, which soon solidifies. This is solid percarbonate of soda. It is crystallized, separated from the small quantity of the water of reaction, and dried.

Determination of Sulphur in Charcoal and Coke.—Herr H. Nowick proposes in Stahl und Eisen the following modification of the Eschka process: Mix 1 gramme of charcoal or coke finely pulverized with 2 grammes of carbonate of soda or of magnesia in a platinum crucible, by means of a platinum wire. Make a vertical canal through the middle of the mass, and heat the lower part of the crucible to the dark red. Introduce oxygen through the crucible cover (Rose crucible), stir up the mass every five minutes, and each time re-establish the central canal. In twenty or thirty minutes the combustion will terminate; then treat the contents of the crucible with water, heat, filter, acidulate slightly, precipitate with barium chloride, and estimate the percentage of sulphur. The operation requires from three to three and a half hours.

Estimation of Formaldehyde.—When formaldehyde acts on a solution of sodium sulphite, caustic soda and the bisulphitic compound of formol are formed. The Chemiker Zeitung gives the method of Herr Lemme for estimating formaldehyde by neutralizing 100 cubic centimeters of a solution of 250 grammes of sodium sulphite in 750 grammes of water, with a few drops of a solution of sodium bisulphite, making use of phenolphthalein as indicator. Then 5 cubic centimeters of the solution of formaldehyde under test are added, which produces a red coloration. The caustic soda formed is titrated with a normal solution of sulphuric acid up to decoloration. The difference between the two may differ from 1-10 to 2-10 of a cubic centimeter, but as 5 cubic centimeters of formol of 40 per cent require 75 cubic centimeters of normal sulphuric acid, the error is inappreciable. Each cubic centimeter of normal acid solution corresponds to 0.03 gramme of formaldehyde.

Synthetic Production of Ammonia.—When air and steam, heated to a temperature of from 300 deg. to 400 deg. C. are passed over iron or other suitable substance, large quantities of ammonia are formed, while the metal is oxidized. A German chemist, Herr Waltereck, has instituted a method for preparing ammonia synthetically in this way. He prefers the temperature of 350 deg. C., a high degree being necessary to prevent the abatement of the intensity of action by cooling. To avoid complete oxidation, it is requisite to reduce the metal intermittently, that is, by an operation repeated at certain intervals, or continuously, by adding a small quantity of a reducing gas to the air and steam passed over the metal. Hydrogen or carbon oxide may be employed for this purpose and passed through the chamber of reaction, or one or both of these gases may be added to the air and steam in quantity sufficient to retard oxidation. If introduced in the chamber, they may be mixed previously or allowed to mingle in the chamber; or the air and the reducing gas may be passed over the metal first, and afterward the steam, and the proportions of air and steam may vary within wide limits. Iron has given the best results, but bismuth and chromium have been found quite suitable.

Manufacture of Barium Hydrate.—A process has been introduced by the Italian Societa Industriale Elettrochimica di Pont Saint-Martin for the production of barium hydrate, founded on a cycle of reactions, thus expressed: Barium sulphate, barium sulphide, barium carbonate, barium carbide, barium hydrate, represented in equations as follows:

(1) $BaSO_4 + 4C = BaS + 4CO$.
(2) $BaS + H_2O + CO_2 = BaCO_3 + H_2S$.
(3) $BaCO_3 + 4C = BaC_2 + 3CO$.
(4) $BaC_2 + 2H_2O = Ba\ (OH)_2 + C_2H_2$.

The process allows of the total elimination of the sulphur by means of a reagent much less costly than those hitherto proposed and produces by-products of value, such as carbon oxide, hydrogen sulphide, and acetylene. Barium sulphide is made to act on carbonic acid. The sulphide is prepared by heating an intimate mixture of barium sulphate and reducing substances in an oven furnished with arrangements for recovering the gases, which are to be utilized in the operation (equation 1). The reaction indicated by equation 2 is then produced. The mass taken from the oven is treated with boiling water, and if pure carbonate is desired, it is decanted and filtered. If pure carbonate is not a desideratum, it is rapidly decanted, in order to separate out the heaviest and most insoluble foreign substances. The purified liquid is then brought into vats or apparatus arranged as saturators and treated with hot carbonic acid until the barium is completely precipitated. The barium carbonate is drawn from the liquid mass in two ways, by filtration with filter presses or by decantation simply. In either case the product obtained is dried and converted into carbide by treating it mixed with charcoal in the electric oven (equation 3). The carbide resulting, treated with water, is converted into barium hydrate on developing acetylene.

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